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ENGINEERING & MINING JOURNAL-PRESS

A CONSOLIDATION OF ENGINEERING AND MINING JOURNAL AND MINING AND SCIENTIFIC PRESS

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Further Facts

By Alfred James

Making Copper 600 Miles North of Vancouver

Granby Consolidated's mining and smelting operations at Anyox, B. C.

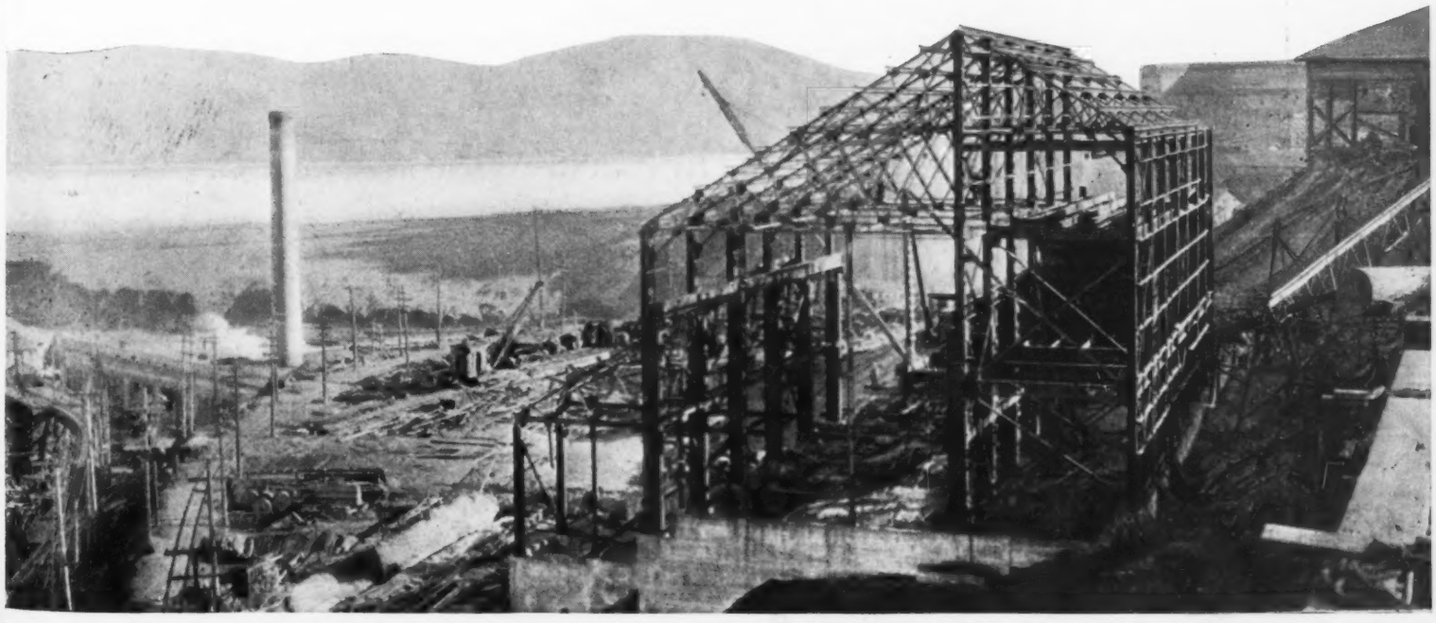
By L. R. Clapp

Marketing of Cobalt Ores and Metal

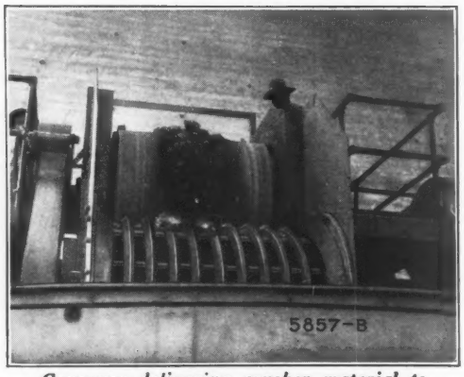
By G. C. Bateman

New Almaden

Views of a Famous Quicksilver Camp



First 1,000-ton unit of Granby Consolidated's concentrator, now nearing completion at Anyox, B. C.



Conveyor delivering crusher material to Burch Grizzly.

Looking down past Burch Grizzly into crusher

An "Ace" for the "Queen"

Out in Bisbee at the Copper Queen is one of the earliest installations of Burch Grizzlies. From the standpoint of expediting separation of the fines from crusher sizes this installation is the "ace" of the Copper Queen.

The Burch Grizzly is absolutely non-clogging, the ingenious arrangement of fixed and loose rings provides accurate spacing at the top while giving complete freedom of release for the fines.

Built in three standard diameters: 36, 48 and 60 inches, and in any width up to ten feet. The ring spacing can be adjusted for specific requirements.

STEPHENS-ADAMSON MFG. CO.
Aurora, Illinois

BURCH Grizzly

ENGINEERING & MINING
JOURNAL-PRESS
JOSIAH EDWARD SPURR, Editor

Volume 116 | New York, December 22, 1923 | *Number* 25

The Emmet Mercury Boiler

A RADICAL IDEA in the generation of power that is now being tried out on a semi-commercial scale may prove of great interest to the mining industries in more than one way. We refer to the use of quicksilver in place of water in a boiler, the quicksilver being vaporized in a boiler at 35 lb. gage and 812 deg. F., allowed to expand through a turbine to 29 in. vacuum and 414 deg. F., then used to generate steam for a separate turbine or other power purposes, and finally all returned to the first boiler as liquid quicksilver. The details of an installation at the Hartford Electric Light Co. are given in this issue on another page. Advantage is thus taken of a much greater temperature range than is possible with steam alone, and the thermal efficiency is about that of the internal-combustion engine—about 1 kw.-hr. from 11,000 B.t.u. Compared with a steam-turbine generating plant operating at 200-lb. steam pressure, a fuel saving of about 50 per cent is made.

The possibilities of this development, which has been made under the direction of W. L. R. Emmet and the General Electric Co., appear startling to say the least. This being the case, the conclusion to which we all leap is that if present experiments are successful, mercury will presently be used in all steam boilers. But to the student of the world's mineral resources there comes a query that may not present itself to the mechanical engineer: how about the supply of mercury?

The Emmet boiler at Hartford holds about 30,000 lb. of mercury. The total production of mercury in the United States in 1919 was 1,601,000 lb., enough to equip only fifty-three boilers like the one already equipped, which has developed about 1,500 kw. or nearly 2,000 hp. In 1922 the mercury produced in the United States had fallen to 478,000 lb., or enough to equip sixteen boilers of the size of the Emmet installation at Hartford. This United States production was to be sure only about one-fifth of the average production for nearly twenty years: nevertheless, it is clear that these twenty years have skimmed the cream from our deposits.

We have a tentative figure of the total amount of boiler horsepower used in the United States in the mining industries at 2,258,000 hp., which, taking the amount of mercury required for the Hartford boiler, would require altogether nearly 34,000,000 lb. of quicksilver, which is more than the total amount of quicksilver produced in the United States in the last twenty-one years—1902 to 1922 inclusive. But the total amount of high-pressure steam-boiler capacity used for all purposes in the United States is 18,000,000 hp., whose equipment would require 270,000,000 lb. of mercury!

The world production of mercury in 1921 was only 4,451,000 lb., enough to equip only 148 boilers of the size of the Hartford plant! The total world's production for fourteen years from 1908 through 1921 inclusive was 110,337,000 lb., or less than half what would be required to change the high-pressure steam boilers of the United States alone to the mercury system.

Enough statistics have been quoted to show how hopelessly inadequate is the hitherto-produced world's supply of mercury to meet the requirements of this suggested new industrial device. The question then arises whether increased demand would not bring on an increased supply. Beyond any question, such a demand would bring about a greatly increased production: but this demand would have to be made in terms of higher prices for quicksilver. We quote currently about $60 per flask of 75 lb.: the average price in 1922 is given by the United States Geological Survey at $57.78, based on *Engineering and Mining Journal-Press* quotations for the year. Owing to the relatively small quantity of quicksilver produced, its price has been subject to wide fluctuations. For many years before the Great War the price was generally below $40 a flask. If the demand for quicksilver for boiler purposes grows, it is inevitable that a skyrocketing of prices will take place.

In 1921 the United States, although producing only 6,339 flasks (475,425 lb.), still remained the third largest producing country in the world, Italy (including the Idria mine) being largest, and Spain (with the Almaden mine) second.

It is evident, therefore, that there is little chance of the production of quicksilver being increased to the enormous degree of allowing it to be used in all steam boilers; also, that the use of the metal in even a few boilers is likely to cause an immense increase in the price.

Revolution in Mexico

COMING SO SOON after the recognition of the Obregon government by Washington, the revolution in Mexico is disappointing. With European affairs in a mess, the increasing stability of government south of the Rio Grande has been comforting. It is really lamentable that one so able as Señor de la Huerta can see no way of electing a president, even though it be himself, save by resort to violence. Obregon, Calles, and he have together constituted Mexico's big three—its political leaders—since order was established. Angered because Calles, with Obregon's support, seemed certain of securing the presidency, which high office de la Huerta seeks quite properly for himself, the latter with his adherents has resorted to arms.

Not long ago, de la Huerta visited New York to talk over matters pertaining to Mexico's debt with bankers here—a preliminary to recognition. On his return, a little mud was thrown for purely political reasons at his conduct of Mexico's finances. Following this, the support by Obregon of Calles, whose sympathies are radical, has precipitated the present disturbance. The conflict, on the surface, is therefore an effort to decide whether progressives, represented by de la Huerta, or radicals, represented by Calles, shall

for a time control the republic's affairs. So far, if reports are true, the Huertistas are progressing with their military campaign. The outcome undoubtedly depends on whether they can secure the backing of big interests, or, in other words, foreign capital. Without such support and in the face of the recognition accorded the existing government on Sept. 1, the present movement seems bound to fail.

It is more important that law and order shall continue to prevail in Mexico than that any particular candidate shall be president. Mexico needs peace and its citizens need continued employment. Great improvement has been made in this direction in recent months. Reports from many parts of the republic indicate unusual activity in mining. Industry of all kinds shows remarkable recovery. Important railway construction is under way. Through his unusual talents Obregon has brought order from chaos and established a stable government. It is to be hoped therefore that, whatever be the political outcome, the present disturbance will be short lived.

A Christmas Suggestion

ALTHOUGH THIS THOUGHT probably appears too late to turn part of the reader's Christmas budget into some channel not already considered by him, we hope that everyone in the mining industries will make gifts of something made of sterling silver. The chances are good that few presents indeed that you or we will make this season have a permanent value and lasting charm. Yet these are just the qualities possessed by silver articles. Compared with the labor or craftsmanship required to fashion a silver ornament, the bullion value is small, so that its worth should not be judged entirely by the amount of silver it contains. Isn't it strange that the Asiatics, the poorest people per capita on earth, feel the romance, intrinsic value, and beauty of silver, while the masses in these United States seem to be apathetic to its attractiveness?

Silver producers want a better market for the white metal. One way to obtain it is to increase the consumption in this country. Then why not begin right in the industry itself? Let the thousands of people whose livelihood depends upon silver grasp every opportunity to buy something made of sterling—not only during the Christmas season but on other occasions.

Scientific Nomenclature

THE DISADVANTAGES and the advantages of a technical nomenclature have been frequently pointed out. Every invention, it goes without saying, springs from a want—a demand. Therefore the coinage of new scientific words out of the Greek, as sciences advance, indicates a need of the advancing scientist for precise terms wherewith properly to define his scientific conceptions. In the hands of the amateur scientist, however, this separate and learned vocabulary becomes a nuisance. He uses it to conceal his own stupidity—from himself and from the world. Yet, in spite of its abuse it is necessary—but like all good medicine, it must not be taken in excess.

Economists complain that they suffer in their scientific work for the lack of precise terminology, and that clear thought is impeded by their having to use commonplace words in a narrow and an inaccurate way. The writers of a recent volume[1] observe, "Exactly what do we mean by consumption, demand, credit, money, wealth, price-levels, profits? These are familiar words of every-day speech; nobody hesitates to use any one of them for fear that he may not have a clear and accurate idea of its meaning. Terms that are equally familiar to the engineering profession, such as the moment of inertia and the radius of gyration, most of us do not attempt to use at all. We know that we do not know what they mean. Various other professions have a similar advantage over economics; their terminology makes it evident that hard study is prerequisite to any sensible discussion of their problems. Most people do not talk glibly about torts or spectrum analyses. About money, however, many people take it for granted that they know all they need to know, since their daily dealings are in terms of money. For this reason they are in special danger of concluding that whatever they do not agree with on this subject is wrong and whatever they do not understand is nonsense. Economics might fare better if it had a forbidding vocabulary of its own, freed from the confusion of everyday speech."

We may draw from this some reflections as to the proper use of terminology in mining and the earth sciences. A sparing and even Spartan use of the higher terminology should be striven for; for if the scientific words degenerate into the common speech, even of scientists, these again acquire double or triple meanings or vague connotations in the minds of different workers. Many an earth scientist and college graduate in geology has no clearer an idea of what metamorphism is than he has of what money is, though he may delude himself that he is on familiar terms with both.

[1] "Money," by W. F. Foster and Waddill Catchings, 1923, p. 15.

Katanga Copper

A DEVELOPED DEPOSIT, containing 4,500,000 tons of metallic copper in ore averaging 6.5 per cent, is something to conjure with, even if it is located in the Belgian Congo, best known in the popular mind for elephants, lions, and cannibals. This is the latest estimate of the ore reserves of the Union Minière du Haut Katanga; but there is little basis for the impression current in some quarters that the company is going to flood the world's market with cheap copper and drive a lot of American producers out of business. It is true that there has been a steady increase in the output of copper from Katanga and that the company is now producing at the rate of about 150,000,000 lb. per year. It is likely that it will continue a gradual increase. Still, there remains a wide margin between 150,000,000 lb. and the 225,000,000-lb. output of Chile and the 240,000,000-lb. output of Utah. And, in spite of these, current consumption and production are not far apart.

Several reasons can be mentioned for questioning the probability of a copper deluge from Africa. Even if the Union Minière wanted to double production in the next few years it is doubtful if it could do so. Its present smelting plant is operating approximately up to capacity; and it takes time to build even comparatively simple plants, particularly in a remote country. Its supplies of high-grade smelting ore, though huge, are not unlimited, and equipment is necessary to mine it and transport it. The design and construction of a leaching plant which ultimately is to be the means of treatment and of a sulphuric acid plant to supply the

necessary reagent will take several years. The company employs ten or twelve thousand natives, which it must obtain from long distances, and it takes time to build quarters and to recruit new men. Doubling the capacity for transportation of wood for boiler fuel is another problem that would be faced.

But even if it were physically possible, it is not certain that the company would consider it good policy to double its output in short order. The lower-grade ore must be mined some time, and it would seem that the coincidental mining and metallurgical treatment of high- and low-grade ore would offer important economies. As a consequence of, among other things, high transportation charges, the cost of Katanga copper delivered in New York is not as low as that of several American producers—not nearly so low that the world market can be ignored. Fifteen-cent as against twelve-cent copper means as much to the Union Minière as to many other producers. After a certain point is reached, no appreciable reduction in production cost can be realized by increasing the scale of operations, so that the maintenance of a good market may be more vital to the financial welfare of a particular company than increased output. The Union Minière has the same marketing problems as any other copper company. It has the same problems of financing plant expansion.

No doubt Katanga copper will be an important factor in the future of the copper-mining industry, just as Chilean copper is, but it costs money to produce it, and the industry is subject to every natural and economic law, just as if it were not in the heart of the Dark Continent. We do not consider it a serious menace to the copper-mining industry in either the next two or in the next fifty years.

Engineering Fact-finding Committees

NO MORE IMPORTANT WORK, in clarifying the situation as to our future mineral policy, is on hand than the estimation of our national ore reserves which has been undertaken by joint committees of the Mining and Metallurgical Society of America and the American Institute of Mining and Metallurgical Engineers. For each metal to be investigated a special national committee of engineers and geologists has been carefully chosen. So far the reports of three of these committees have been printed—those on petroleum, on chrome, and on graphite. We have already published extracts from the reports of all these committees.

So far, the report of the chromite committee, consisting of Albert Burch and E. F. Burchard, is the most satisfactory. Given a definite task, they have performed it—that of stating in plain figures their estimate of the chromite resources of the United States: and they have classified these estimated reserves sensibly. However wide of the mark they may prove to be, or however close, there are the figures; and of one thing we may be sure: that they are the best figures obtainable, and therefore the figures to which we must tie.

The report of the petroleum committee is disappointing: with regard to petroleum reserves it limits itself to generalities, not furthering our definite knowledge; and it is devoted largely to recommendation of policy. But these committees are engineering committees, formed for the purpose of fact-finding, not of defining policies: they are appointed for presenting facts, or engineering estimates of facts, which may serve as a basis for all discussion and any and all policies. The failure to estimate, in the case of this committee, is especially disappointing, since it is known that some members of the committee have very definite views of our petroleum reserves—which, indeed, have been publicly expressed. The report of the graphite committee is also vague as to estimates of reserves; no figures are undertaken, which is again a side-stepping of the job of the committee, though with excuse for bewilderment in view of the undeveloped condition of our graphite reserves. The report is sound, but contains nothing that is new.

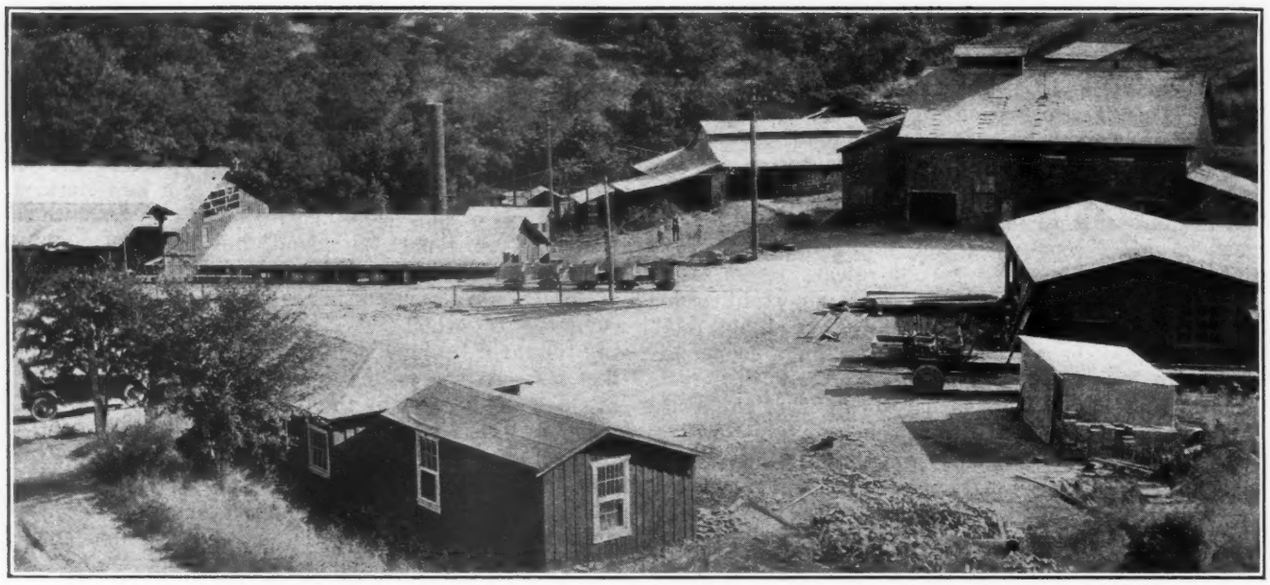
Great interest centers in the report of the manganese committee, of which Mr. C. M. Weld is chairman. During the tariff hearing in Congress, there was much conflict between the estimates of the manganese reserves of the United States by the Geological Survey and those made by the Mining Congress. The estimate of the former was about one-tenth that of the latter. Probably the estimates of the Geological Survey were overconservative—indeed, in one important point they were proved to be so; but it is the universal opinion among mining engineers that the estimates of the Mining Congress were extravagantly large. Indeed, as the estimates of the attorney for the interested parties, it would be expected that they would be so. Thus, the joint manganese committee, of which Mr. Weld is chairman, has precedents.

Stage fright and too large committees, as we see it, have helped to stultify the advantages of many recently appointed engineering or partly engineering committees. The Coal Commission is one example which we have not mentioned above, but which is very much in the public mind. We note that the chrome committee, which, as we state above, laconically delivers the goods, and retires—consisted of only two members, both forthright and impartial men; and this suggests that similar committees in the future should be made small—one or two or three. And the second precept for engineering fact-finding committees should be: "Deliver your facts as succinctly and clearly as you know how; and for the love of engineering, beware of stage fright!"

The prayer of each engineer who has a public task of fact-finding given him, as he lies down each night, should be "O Lord, give me backbone; and deliver me from the sin of pussy-footing."

Mining Engineers as Mint Officials

IT IS WORTHY OF NOTE that two mining engineers recently have been appointed to government posts of technical importance. Robert J. Grant has been promoted from superintendent of the Denver Mint to Director of the Mint, and he has been succeeded at Denver by Frank E. Shepard. Both appointments are non-political, and are based on qualifications for the work to be done. Grant proved his ability while superintendent of the Denver Mint and is promoted accordingly by Mr. Mellon. Incidentally, the job of Director of the Mint carries a salary of $5,000 only, which is small for an official that has charge of five billion dollars in hard money. The Director of the Mint in Mexico receives $12,500, in gold, and has charge of one plant, whereas our Director has charge of three mints and eight assay-offices. The salary was fixed at $5,000 when the office was created in 1853, since when the cost of living at Washington has increased out of all proportion to the salaries paid to responsible government officials.



Plant of the New Almaden company, where cinnabar is converted into quicksilver

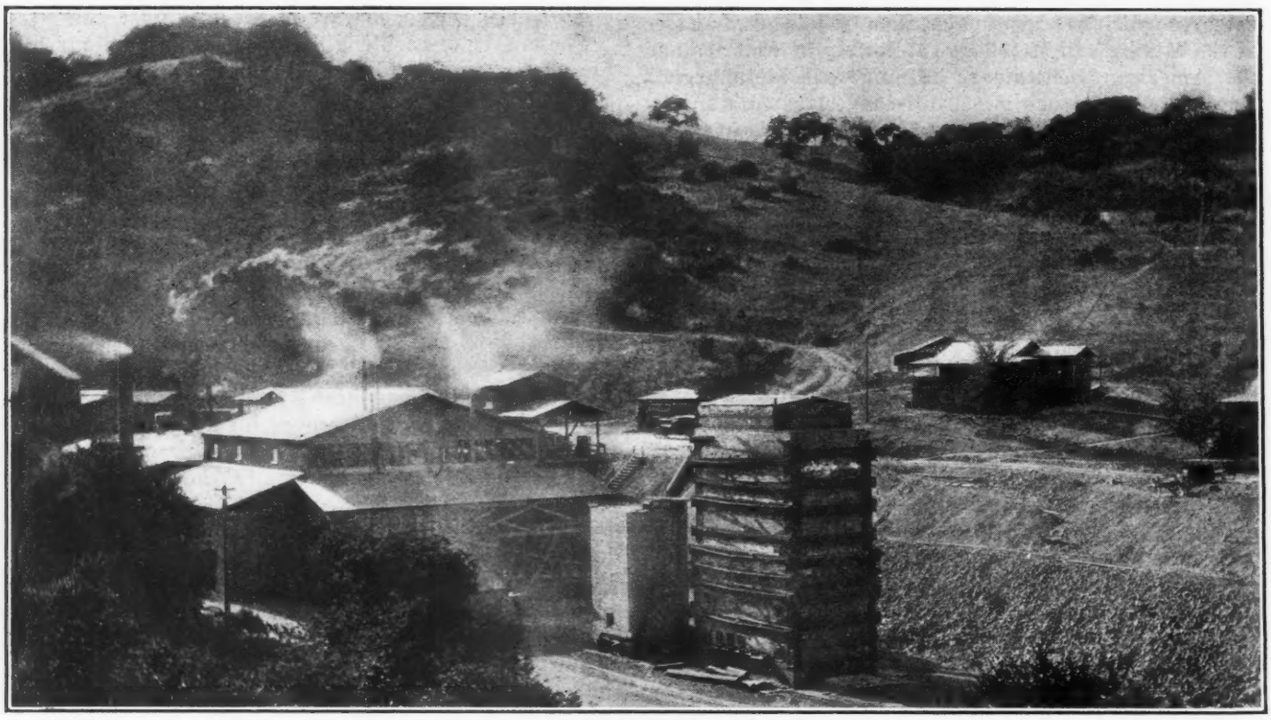
New Almaden, a Century-old Quicksilver Camp

By Andrew R. Boone
Stanford University, California

NEW ALMADEN, the world's second richest and largest quicksilver mine, recently celebrated its centennial. The mine, in Santa Clara County, near San Jose, Calif., was discovered by Digger Indians about a century ago and is named after the well-known Spanish mine at Almaden in the Province of La Mancha. The property has produced in the 100 years of intermittent working quicksilver to the value of $75,000,000 and a new shaft recently sunk is expected to produce still more.

Although this mine, in a romantic and picturesque California setting, has yielded such a wealth of quicksilver, few persons today realize what a part it has played in the development of the Golden State; how, at one time, it was the center of California politics; how, at still another time, it became internationally famous when Emperor William of Germany, grandfather of ex-Kaiser Wilhelm, was called upon to settle a dispute as to title.

One hundred and one years ago the mine first became known to white men, when Indians told two Spaniards of the ore. Two decades later Andreas



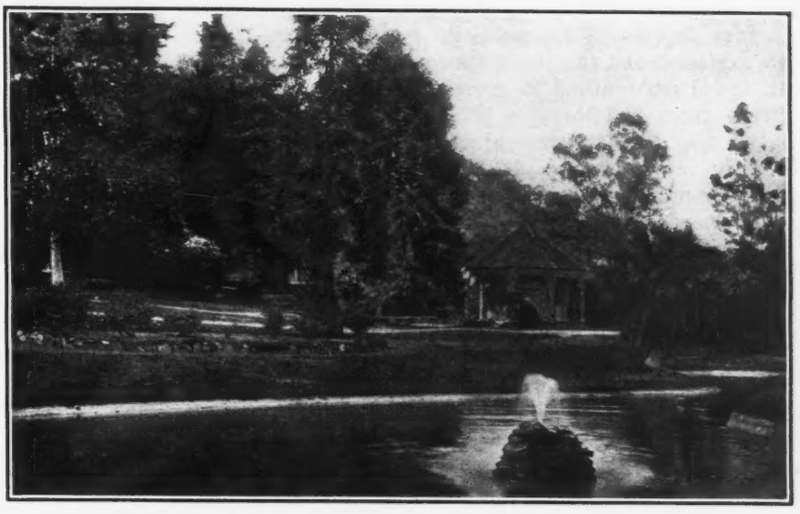
Another view of plant, showing furnace

Castillero, a Mexican officer, filed a discoverer's claim, formed a company under Spanish and Mexican laws, and employed William G. Chard, an American, to separate and extract the mercury from the ore. Chard is said to have employed very crude methods of reduction. In 1845 Castillero sold his interest to an English firm. Long and involved litigation ensued. The English company found itself in the unenviable position of drawing the cross-fire of various other claimants. To protect the company, the manager bought off two of the claimants, and even then the matter became very serious when the foreign claimants indicated that they would not accept United States Supreme Court orders and decisions. Eventually it was suggested that Emperor William be asked to referee the dispute, the claimants to abide absolutely by his decision. Months passed without any further disorders on the property, and when the Emperor finally decided the question, he awarded the property to the English company, $1,500,000 to be paid the Mexican claimant. No later titular difficulties arose, and from that date on development was carried on successfully.

Captain Henry Halleck, who became famous as a major general during the Civil War, constructed the first furnaces while he served as general manager of the mine, and at the outbreak of the war the Quicksilver Mining Co., of New York, bought the mine and improvements, including 8,500 acres of land, for $1,700,000. The new ownership brought Samuel F. Butterworth, of Washington, D. C., into the picture, who controlled the destinies of the new project until J. B. Randol, of New York, succeeded him as president and controlling owner. Thomas Derby, of San Jose, succeeded Mr. Randol in 1894, remaining in the position until 1912, when the present owners, the New Almaden company, took over the property.

Few spots around mines are more beautiful than the buildings and grounds of New Almaden. It seems as though the hand of a wandering magician had touched the bushes and trees and vines, dropped into their places as the years have rolled on, leaving each as perfect as though molded by the hand of a skilled artisan. Fruit trees and shade trees add to the general tone of rest one notices when arriving at New Almaden, while back of Casa Grande, circling terraced lawns lead down to an artificial lake and fountain. Beside the little lake is an Oriental tea house, for many years weatherbeaten and rambling, still an example of the days when pomp and show were the accepted thing. The tea house came to the premises during the days the English company held sway, the gift of the Emperor of China. He gave it to the company in return for favors extended to his envoy in California, sending men a long distance to see that the little building, inlaid with mother-of-pearl, was properly put together.

Casa Grande, residence of the manager



Grounds back of Casa Grande, showing the tea house given by Chinese Emperor to the English company that purchased the mine from the Spanish grantees

Old adobe houses at Hacienda, formerly homes of employees

Liquid Oxygen Explosives —Further Facts

A Study of the Energy Evolved by Various Combustibles That May Enter Into Their Composition

By Alfred James
Consulting Engineer, London, England

DURING the last few months I have written a book, "Liquid Oxygen Explosives," for the same purpose that I wrote my book "Cyanide Practice." It is convenient to have at hand, available for professional practice, the *modus operandi* and results of the work carried out in various parts of the world, with calculations as to efficiency, cost, and some examination of the theoretical considerations involved.

Unfortunately, it costs much more to publish a book than was the case twenty years ago, and I do not therefore propose to assume this expense. But I feel that the calculations as to the theoretical efficiency of certain combustibles may be of special interest at this juncture, in view of the publicity recently given to the new explosive and the investigations now being carried out, and I am induced to present to the industry this extract from chapter five of my book in the hope that it may lead to some practical investigation, particularly into wave speeds, by the Bureau of Mines and other public disinterested bodies engaged in testing out the new explosive.

I should like to add that much of this article is the work of Dr. E. Fyleman, whose interesting contribution on the subject in "Industrial Gases"[1] compelled me to procure his valuable co-operation.

An explosive is a substance, or an intimate mixture of substances, capable of undergoing rapid chemical change with the evolution of much heat energy and of a large volume of gas or vapor. The technical effect of the explosive is dependent on these two factors, and also on the rapidity of the reaction. "There is far more energy obtainable by burning a pound of coal than by firing a pound of blasting gelatine; the coal evolves on burning some 7,000 to 8,000 Centigrade heat units and the blasting gelatine some 1,400 heat units only. But whereas under ordinary conditions the coal is burnt during a considerable time interval, the blasting gelatine, when properly detonated in a bore hole, liberates the whole of its stored-up energy in a thousandth or ten-thousandth of a second. The consequence is that if the reaction takes place in a confined space a shattering blow is delivered on to the containing walls, which is the effect desired. The rapidity of the explosion, and consequent violence of the mechanical effect, can be regulated more particularly by alterations in the character of the explosive charge, and liquid oxygen explosives lend themselves particularly well to such modifications."[2]

The total energy output of various explosives may be somewhat roughly compared by multiplying together the total heat evolved and the volume of resultant gas and vapor; for comparative purposes the resultant volumes may be compared at any convenient standard temperature and pressure, as all gases and vapors at a point well above their liquefaction point expand or contract to an equal extent for equal alterations of temperature and pressure. In actual calculation it is convenient to compare such gas volumes at 0 deg. C. and a pressure of 76 cm. of mercury, which is about the average atmospheric pressure at sea level. The amount of heat energy evolved by a given chemical reaction is dependent only on the original physical condition of the reacting substances and the final physical and chemical condition of the products; it is entirely independent of the rapidity of the reaction or of the course which it may take in other respects. This fact facilitates calculation.

Amount of Heat Evolved Constant

Returning to our coal, one may burn one pound of coal quietly on the firebars in the course of many minutes, or inject it in as many seconds in the form of powdered fuel mixed with air and so burn it, or again one may first mix it intimately in the form of fine dust with excess of air or oxygen and by firing the mixture obtain a violent explosion, lasting perhaps a hundredth of a second; but in all cases the total amount of heat evolved is the same, assuming total combustion to carbon dioxide, steam, nitrogen, and ash and that the final products are at the same temperature and pressure, and consequently occupy the same volume; otherwise clearly the amount of *mechanical* work exerted against atmospheric pressure would vary from case to case, and this would be reflected in the output of heat energy. If instead of burning it in air slowly we powder it very finely, mix it with a suitable proportion of liquid oxygen which is in an extraordinarily effective form, concentrated almost one thousand-fold as compared with the gas at ordinary pressure and detonate the mixture with an ordinary detonator, we obtain a violent explosion. Coal is not the most suitable combustible for the purpose, a more porous material, such as carbon black charcoal or sawdust, being better, as will be explained later, but all liquid oxygen explosives derive their energy from the oxidation of carbon, various carbon compounds, aluminum and other combustible compounds or elements in oxygen, and depend on the extremely rapid combustion of such substances, in themselves harmless and comparatively stable, when mixed with liquid oxygen and fired.

In order to explain the principles involved in determining the heat energy evolved, we will consider the case of the ordinary liquid oxygen explosive consisting of a mixture of finely divided carbon and liquid oxygen. The modern chemical equation for the complete combustion of carbon in oxygen, which takes account of the heat energy evolved, is, at 15 deg. C. as follows:

$$C + O_2 = CO_2 + 97 \text{ calories.}$$

This equation supplies the following information: One atom of carbon is oxidized by one molecule of oxygen gas containing two atoms of oxygen, to form one molecule of carbon dioxide with the evolution of ninety-

[1] London, December, 1922.
[2] E. Fyleman, "Industrial Gases," London, December, 1922.

seven calories of heat energy; this is on the assumption that the carbon and oxygen are at a temperature of 15 deg. C. at starting (the small amount of heat necessary locally to start the reaction being allowed for) and that the products are allowed to expand to atmospheric pressure and give off heat until they resume atmospheric temperature. In more practical terms, 12 g. of carbon burn and combine with $2 \times 16 = 32$ g. of oxygen, measuring 22.4 liters at 0 deg. C. and 1 atmosphere pressure, to form $12 + 32 = 44$ g. of carbon dioxide, measuring 22.4 liters under the same conditions, with the evolution of as much heat as will raise the temperature of 97 kg. of water by 1 deg. C. The numerical relations with regard to weights and heat units are equally true if expressed in English pounds and Centigrade heat units (C.h.u.).

It will be noticed that there is no alteration in the gas volume; this is due to the fact that equal volumes of all gases under the same conditions of temperature and pressure occupy the same volume and that also, in this particular case, the number of gaseous molecules present is not altered by the reaction; in other words, one molecule of oxygen forms one molecule of carbon dioxide when it reacts with uncombined carbon. The heat of reaction in this case is ninety-seven calories.

When, as in the present case, the reaction consists of the complete combustion of the material in oxygen or air, this quantity is also referred to as the heat of combustion, and it will be noted that it refers not to the unit weight of the combustible material but to its gram-atom, or gram-molecule in the case of a compound—that is, to the atomic or molecular weight expressed in grams. For technical purposes, and in the case of materials of indefinite chemical composition, such as ordinary fuels, the figure used is the number of calories evolved on burning 1 kg. (1,000 g.) and is known as the calorific value. This is obviously derived from the heat of combustion by multiplying by 1,000 and dividing by the atomic or molecular weight of the substance burnt. Thus the heat of combustion of carbon, atomic weight 12, is as we have seen ninety-seven calories and its calorific value is $97{,}000 \div 12 = 8{,}080$. In the same way the heat of combustion of naphthalene, of molecular weight 128, is 1,194, and its calorific value is therefore $1{,}194{,}000 \div 128 = 9{,}328$.

LO Explosives Fired at Low Temperature

Liquid oxygen explosives are not fired at the ordinary atmospheric temperature, as are other explosives, but necessarily at a temperature of —183 deg. C., the boiling point of liquid oxygen. Therefore, in calculating the heat evolved at 15 deg. C., the atmospheric temperature, we must, to have a proper comparison, deduct from the heat of reaction at ordinary temperature the heat required to heat the ingredients from —183 deg. to 15 deg. C.—that is, through 198 deg. C.—and also the heat necessary to convert the liquid oxygen into oxygen gas at the same temperature. On the principles explained earlier in this article this is perfectly legitimate, as the same ultimate net energy output is obtained whether we first warm up our ingredients to atmospheric temperature and gasify our oxygen, and then fire, or whether we fire in the cold, so long as we finish with the products at the same temperature and (atmospheric) pressure in both cases.

To make these corrections we must know the heat of evaporation of liquid oxygen; that is, the number of calories required to evaporate 1 kg. of that liquid; and also the specific heat of gaseous oxygen at constant pressure; that is, the number of calories required to raise the temperature of 1 kg. of oxygen gas, at constant pressure, through 1 deg. C. The condition "at constant pressure" is required, as were the volume maintained constant the amount of heat required would be less, for in that case the gas does no mechanical work in expanding against atmospheric pressure. We also require the specific heat of amorphous carbon; the heat of combustion of carbon has already been discussed.

Liquid Oxygen's Heat of Evaporation Low

The heat of evaporation of liquid oxygen is 51. This is extremely low, as we may realize by comparing it with the corresponding figure for water, which is 536 at 100 deg. C.—namely, over ten times as large, a fact the importance of which will be pointed out later. The specific heat at constant volume of oxygen over the temperature range in question is approximately 0.22—that is, over this range 0.22 calories are required to raise the temperature of 1 kg. of oxygen gas through 1 deg. C. The specific heat of carbon over the same temperature range is approximately 0.24.

Thus, assuming for the moment that in our cartridge we have nothing present but pure carbon and the exact amount of liquid oxygen necessary for its complete combustion to carbon dioxide, we have per 1,000 gram-atoms (kilogram-atom) of carbon:

	Calories
Heat evolved	97,000
Heat absorbed	
(1) Heating 12 kg. carbon, of specific heat 0.24 through 198 deg. C., $12 \times 0.24 \times 198$	= 570
(2) Evaporating 32 kg. liquid oxygen of heat of evaporation 51, 32×51	= 1,630
(3) Heating 32 kg. of gaseous oxygen (specific heat 0.22) through 198 deg. C., $32 \times 0.22 \times 198$	= 1,390
Total heat absorbed	3,590
Net heat of reaction	93,410

This corresponds to $12 + 32 = 44$ kg. of our supposed mixture. Therefore per kilogram of explosive our net heat of reaction would be $93{,}410 \div 44 = 2{,}123$ calories per kilogram.

It will be observed that the heat absorbed owing to the initial low temperature of the ingredients is only 3.7 per cent of the whole, practically an almost insignificant quantity.

The volume of gas evolved per kilogram, measured at 0 deg. C. and 76 cm. of mercury, is, as already explained, equal to that of the original oxygen if gasified, and is consequently, per kilogram of the mixture, $22.4 \times 1{,}000 \div 44 = 509$ liters. Multiplying this by 2,123, the net heat evolved, we obtain a rough figure for the total energy as above described $HV = 1.08 \times 10^6$.

The corresponding figures for dynamite No. 1 are:

$H = 1{,}170$ calories; $V = 536$ liters.

Total energy $HV = 0.627 \times 10^6$.

Excess of Liquid Oxygen at Moment of Firing Necessary

The above figures do not quite correspond with practical conditions, owing to the fact that in practice it is desirable so to arrange matters that at the moment of firing there shall always be an excess of liquid oxygen beyond that required to oxidize all the carbon to carbon dioxide; the reason for this is that any deficiency materially affects the power of the explosive and leads to the production of objectionable carbon mon-

oxide together with the harmless carbon dioxide. If we assume a 10 per cent excess of liquid oxygen—that is, 12 parts of carbon and 35.2 parts of liquid oxygen, or 2.93 parts of the liquefied gas per unit weight of the combustible, which is probably in very close accordance with the conditions in ordinary careful practice—we obtain the following figures:

	Calories
Heat evolved	97,000
Heat absorbed	
(1) Heating 12 kg. carbon through 198 deg.	= 570
(2) Evaporating 35.2 kg. liquid oxygen, 51 x 35.2	= 1,790
(3) Heating 35.2 kg. gaseous oxygen through 198 deg. C., 35.2 x 0.22 x 198	= 1,530
Total heat absorbed	3,890
Net heat of reaction	93,110

This corresponds to 12 + 35.2 = 47.2 kg. of the mixture. Therefore, per kilogram of explosive the net heat of reaction is 93,110 ÷ 47.2 = 1,973 calories per kilogram.

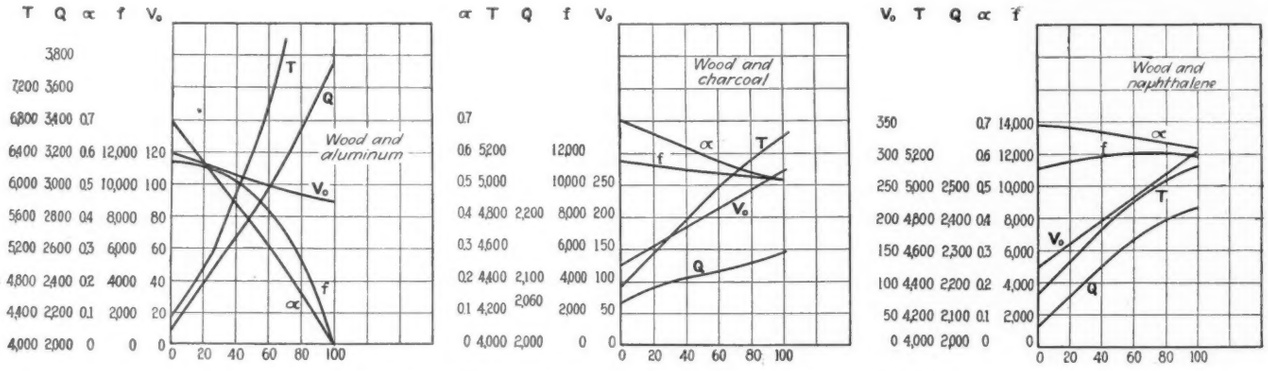
Even in this case the heat absorbed owing to the initial low temperature is only about 4.2 per cent of the whole.

The commission's graphs are given in the accompanying cuts. In these

T = Absolute temperature of explosion CO.
Q = Calorific value (cal. per kg.).
V_o = Volume of gas.
$\alpha = \frac{V_o}{1.000}$ i.e., Co-volume.
f = Theoretical force.

The outstanding impression resulting from these graphs is the extraordinary inefficiency of a cartridge consisting of 100 per cent aluminum, in spite of the remarkably high temperature of explosion and the calorific value; the reason for this will be explained later. The efficiency of naphthaline, even in quantities as high as the absorbent capacity of the cartridge will permit, also attracts attention.

The very great explosive power of liquid oxygen explosives is due to the fact that materials of unusually high calorific power, such as carbon itself, naphthaline,



Graphs obtained by the Commission des Substances Lheure

The gas evolved per kg. measured at 0 deg. C. and 76 cm. mercury, V, is in this case

$$\frac{35.2 \times 1{,}000 \times 22.4}{32 \times 47.2} = 522 \text{ liters.}$$

In this example our rough figure HV for the total energy evolved is $1{,}973 \times 522 = 1.03 \times 10^6$. Thus, with 10 per cent of additional oxygen we obtain a 5 per cent diminution only in the efficiency; as only 3.5 to 4 parts by weight of oxygen per 1 part of charcoal is ordinarily employed, there is thus little likelihood of serious loss of efficiency through this cause.

Results Agree With German Tests

These results show the liquid oxygen-carbon explosive to be about 1.6 times as powerful as the dynamite, in agreement with the German tests and other observed results; but other factors, such as the velocity of detonation—wave speed—also play an important part, and, in general, this method of numerical comparison (by multiplying gas volume at 0 deg. C. by the calorific value) is approximate only and is modified in practice by the greater wave speed of dynamite and by the greater space occupied in the drill holes by the stiff light liquid oxygen cartridges.

The Commission des Substances Lheure[1] states a wave propagation with certain cartridges of close on 1,600 meters and a coefficient of practical efficiency at least equal to that of gelatin dynamite. It finds that practically no carbon monoxide is formed on detonation.

[1]Lheure, December, 1922, Bull. Soc. Ing. Civ. de France.

and aluminum, are employed and directly burnt in liquid oxygen. Had liquid oxygen a large latent heat of vaporization, as has, for instance, water, this would seriously detract from the net energy of the explosion, but, as has been shown, the heat requirements for gasification and for heating the ingredients to normal temperature are quite unimportant. As against this we have the advantage of almost instantaneous combustion in oxygen at a concentration about 800 times as great as in the gas at normal temperature and pressure and about 3,800 times as great as in ordinary air.

Explosives of the ordinary type hitherto used have the oxygen which they require for decomposition attached chemically to their molecules and are in a sense already partly oxidized; all that occurs on explosion in these cases is a molecular rearrangement, with decomposition into simple gases, a completion of the oxidation process; the heat of reaction is thus much lower and the effect is therefore much less powerful weight for weight.

As a further example of the calculation of net heats of reaction, we may now consider the case of naphthaline, exploded with the theoretical amount of liquid oxygen. The equation in this case is:

$C_{10}H_8 + 12O_2 = 10CO_2 + 4H_2O + 1{,}194$ cal.; that is, 128 g. of naphthaline burn in $12 \times 32 = 384$ g. of oxygen, measuring $12 \times 22.4 = 269$ liters at normal temperature and pressure, and produce $10 \times 44 = 440$ g. of carbon dioxide, measuring $10 \times 22.4 = 224$ liters under the same conditions and $4 \times 18 = 72$ g. of water vapor, which, if gaseous, would measure under the same

conditions $4 \times 22.4 = 89.6$ liters, and actually a volume in proportion, at such high temperatures as are really produced by the explosion. The equation further informs us that 1,194 calories of heat are also evolved. Beyond the data already noted, we now require the specific heat of naphthaline, which is 0.31 in the solid state. Then we have for our heat balance, per 1,000 gram molecules:

	Calories
Heat evolved	1,194,000
Heat absorbed	
(1) Heating 128 kg. naphthaline specific heat 0.31 through 198 deg. C., 128 x 0.31 x 198 =	7,850
(2) Evaporating 384 kg. liquid oxygen, 51 x 384 =	19,600
(3) Heating 384 kg. oxygen gas through 198 deg. C., 384 x 0.22 x 198 =	16,700
Total heat absorbed	44,150
Net heat of reaction	1,150,000

(Figures of no value are omitted.)

The total weight of explosive mixture is 128 + 384 = 512 kg. and the net heat of reaction per kilogram is 1,150,000 ÷ 512 = 2,246 calories per kilogram. The gas volume per kilogram of mixture, V, is 14 x 22.4 x 1,000 ÷ 512 = 612.5 liters. HV is therefore 2,246 x 612.5 = 1.375 x 10^6.

These figures all are slightly larger than those for carbon, mainly due to the fact that naphthaline is slightly endothermic—that is, the compound contains slightly more chemical energy than its constituent elements contain.

The case of aluminum is peculiar, as we have seen from the graph. Although this metal evolves a very large amount of heat on oxidation, there are no gaseous products; its value in a liquid oxygen explosive can therefore be calculated, on the lines indicated, only by assuming either excess of liquid oxygen or the presence of other compounds which yield gaseous products. The equation for the oxidation of aluminum is: $Al_2 + O_3 = Al_2O_3 + 380$ cal. This amount of heat is yielded by 54.2 g. of aluminum and 48 g. of oxygen. The heat balance for the explosion of 1,000 gram-atoms of a mixture of aluminum and liquid oxygen in theoretical proportions is therefore as follows:

	Calories
Heat evolved	380,000
Heat absorbed	
(1) Heating 54.2 kg. aluminum (specific heat 0.205) through 198 deg. C., 54.2 x 0.205 x 198 =	2,200
(2) Evaporating 3 x 16 kg. liquid oxygen, 48 x 51 =	2,450
(3) Heating 48 kg. of gaseous oxygen through 198 deg. C., 48 x 0.22 x 198 =	2,090
Total heat absorbed	6,700
Net heat of reaction	373,300

The weight of the explosive mixture is 54.2 + 48 = 102.2 kg. and the heat evolved per kilogram is therefore 373,300 ÷ 102.2 = 3,653 calories per kilogram.

The high value thus obtained explains the marked manner in which the power of a liquid oxygen explosive should be enhanced by the addition of even a small proportion of aluminum powder, but the intense heat generated by aluminum is gasless and therefore ineffective for explosive purposes—except in so far as it affects the power of the explosive by increasing the wave speed.

If we add liquefied oxygen to be expanded into gas we only reduce the calorific value. Thus, assuming a cartridge to absorb four times the oxygen theoretically necessary, the calorific value is reduced to 1,463 and HV to 0.599×10^6. With thrice theoretical the calorific value is 1,840 and the HV 0.629×10^6. Twice theoretical gives HV 0.549×10^6 and 2,455 cal. per kilogram.

The wrappings of liquid oxygen cartridges usually consist of some form of paper, which for all practical purposes we may consider to be cellulose $C_6H_{10}O_5$. It will therefore be advisable to calculate the quantity HV for cellulose.

The equation for the combustion of this substance is: $C_6H_{10}O_5 + 6O_2 = 6CO_2 + 5H_2O + 627$ calories. Translated into ordinary language this means that 162 g. of cellulose, burnt in 192 g. of oxygen, form $6 \times 22.4 = 134.4$ liters of carbon dioxide and $5 \times 22.4 = 112$ liters of steam, both volumes being reduced to normal temperature and pressure, but the products being assumed to remain gaseous. In addition, 627 calories of heat are liberated, and it may be noted that in this case, as in that of naphthaline, the figure for the heat of combustion which is used is one which assumes that the water vapor which is formed remains gaseous, and not the somewhat higher figure which is obtained if this is supposed to be allowed to condense. The specific heat of cellulose within the range in question may be taken as about 0.3.

We thus obtain the following figures showing the heat relations for the combustion of 1,000 gram-molecules of cellulose in liquid oxygen:

	Calories
Heat evolved	627,000
Heat absorbed	
(1) Heating 162 kg. cellulose, specific heat 0.3 through 198 deg. C., 162 x 0.3 x 198 =	9,620
(2) Evaporating 192 kg. liquid oxygen, 51 x 192 =	9,800
(3) Heating 192 kg. oxygen gas through 198 deg. C., 192 x 0.22 x 198 =	8,350
Total heat absorbed	28,770
Net heat of reaction	598,200

The total weight of explosive mixture is 162 + 192 = 354 kg. and net heat of reaction per kilogram is 598,200 ÷ 354 = 1,690 cal. per kilogram.

The gas volume, per kilogram of mixture, is 11 x 22.4 x 1,000 ÷ 354 = 696 liters.

HV is therefore 1,690 x 696 = 1.176 x 10^6.

Summarizing the results already calculated, we obtain the following tables:

	Atomic or Molecular Weight	Weight of Oxygen Required	Net Heat of Reaction, in Calories per 1,000 Gram-Molecules	Total Gas Evolved per 1,000 Gram-Molecules Reduced to Normal Temperature and Pressure, Liters
Carbon	12 (1 atom)	32	93,410	22,400
Naphthaline	128	384	1,150,000	14 x 22,400
Cellulose	162	192	598,200	11 x 22,400
Aluminum	54.2 (2 atoms)	48	373,300	Nil.

Per kilogram of combustible material:

	Weight of Liquid Oxygen Required	Net Heat of Reaction in Calories	Total Gas and Vapor in Liters, Reduced to Normal Temperature and Pressure
Carbon	2.67	7,784	1,867
Naphthaline	3.00	8,984	2,450
Cellulose	1.185	3,699	1,521
Aluminum	0.886	6,890	Nil.

The calculation of HV, our approximate index of the comparative effectiveness of variations in the combustible for any given combination, is readily made on the basis of these figures; the method of doing this will be evident from the following examples:

Cartridge No. 1. 28mm. x 300 mm. cellulose wrapper, weight 3.6 g.; carbon black filling, weight 40 g.

The liquid oxygen required for this cartridge is:	Grams
For the cellulose 3.6 x 1.185 =	4.27
For the carbon 40 x 2.67 =	106.8
Total oxygen	111.1
Cartridge	43.6
Cartridge plus oxygen	154.7
Net heat of reaction per 1,000 cartridges:	**Calories**
From 3.6 kg. cellulose 3.6 x 3,699 =	13,300
From 40 kg. carbon 40 x 7,784 =	311,400
Total heat of reaction	324,700
Total gas and vapor at N.T.P.:	**Liters**
From 3.6 kg. cellulose 3.6 x 1,521 =	5,480
From 40 kg. carbon 40 x 1,867 =	74,680
Total volume	80,200

These figures refer to 154.7 kg. of cartridges plus liquid oxygen. Therefore heat × volume per kg. of explosive mixture = $HV = 324{,}700 \times 80{,}200/(154.7)^2 = 1.088 \times 10^6$.

Cartridge No. 2. All cellulose. This has already been dealt with. $HV = 1.176 \times 10^6$, a rather larger quantity.

Cartridge No. 2A. Cellulose plus an excess of liquid oxygen equal in amount to the oxygen theoretically necessary for the reaction.

	Calories
Heat evolved	627,000
Heat absorbed	
(1) Heating 162 kg. cellulose specific heat 0.3 through 198 deg. C., $162 \times 0.3 \times 198$	= 9,620
(2) Evaporating 192 + 192 kg. liquid oxygen, 51 x 384	= 19,600
(3) Heating 192 + 192 kg. oxygen gas through 198 deg. C., $384 \times 0.22 \times 198$	= 16,700
Total heat absorbed	45,920
Net heat of reaction	581,080 (say 580,000)

The total weight of explosive mixture is 162 + 192 + 192 = 546 kg., and the net heat of reaction is 580,000 x 546 = 1,062 calories per kilogram. The gas volume is $\frac{17 \times 22,400}{546} = 700$ and $HV = 700 \times 1,062 = 0.743 \times 10^6$.

Cartridge No. 3. 23.6 g. cellulose; 20 g. aluminum.

Liquid oxygen required is:	Grams
For the cellulose 23.6×1.185	= 28.0
For the aluminum 20×0.886	= 17.7
Total oxygen	45.7
Total weight of mixture 45.7 + 43.6	= 89.3

Net heat of reaction per 1,000 cartridges:	Calories
From 23.6 kg. cellulose $23.6 \times 3,699$	= 87,400
From 20 kg. aluminum $20 \times 6,890$	= 137,380
Total heat of reaction	224,780

Gas and vapor evolved:

From 23.6 kg. cellulose, $23.6 \times 1,521 = 36,000$ liters.
From 20 kg. aluminum, nil.
$HV = 225,200 \times 36,000 \div (89.3)^2 = 1.015 \times 10^6$.

Cartridge No. 4.	Grams
Cellulose wrapper	3.6
Carbon black	20
Naphthaline	10
Aluminum	10
Total	43.6

Oxygen required	Grams
For cellulose 3.6×1.185	= 4.3
For carbon 20×2.67	= 53.4
For naphthaline 10×3.00	= 30.0
For aluminum 10×0.886	= 8.9
Total oxygen	96.6

Total mixture 43.6 + 96.6 = 140.2 grams.

Per 1,000 cartridges, heat of reaction is:	Calories
From cellulose $3.6 \times 3,699$	= 13,300
From carbon $20 \times 7,784$	= 155,700
From naphthaline $10 \times 8,984$	= 89,840
From aluminum $10 \times 6,869$	= 68,690
Net heat of reaction	327,490

Total gas and vapor at N.T.P.:	Liters
From cellulose $3.6 \times 1,521$	= 5,490
From carbon $20 \times 1,867$	= 37,340
From napthaline $10 \times 2,450$	= 24,500
From aluminum	nil
Total	67,330

$HV = 327,500 \times 67,330 \div (140.2)^2 = 1.12 \times 10^6$.

Cartridge No. 5. Cellulose, 23.6 g.; naphthaline 20.0 g.

Oxygen required:	Grams
For cellulose 23.6×1.185	= 28
For naphthaline 20×3.00	= 60
Total	88
Total mixture = 43.6 + 88 g.	= 131.6

Per 1,000 cartridges heat of reaction is:	Calories
Cellulose $23.6 \times 3,699$	= 87,296.4
Naphthaline $20 \times 8,984$	= 179,680
Net heat of reaction	256,976.4

Total gas and vapor at N.T.P.:	Liters
From cellulose $23.6 \times 1,521$	= 35,895.6
From naphthaline $20 \times 2,450$	= 49,000
Total	84,895.6

$HV = 266,976 \times 84,896 \div (131.6)^2 = 1.309 \times 10^6$.

Cartridge No. 6.	Grams
Cellulose	20
Naphthaline	20
Aluminum	2
Total	42

Oxygen required:

$20 \times 1.185 = 23.700$
$20 \times 3 = 60$
$2 \times 0.886 = 1.772$

Total oxygen 85.5

Total = 42 + 85.5 = 127.5 g.

For 1,000 cartridges, heat of reaction:	Calories
Cellulose $20 \times 3,699$	= 73,980
Naphthaline $20 \times 8,984$	= 179,680
Aluminum $2 \times 6,869$	= 13,738
Net heat of reaction	267,398

Total gas and vapor at N.T.P.:	Liters
From cellulose $20 \times 1,521$	= 30,420
From naphthaline $20 \times 2,450$	= 49,000
From aluminum	nil
Total	79,420

$267,398 \times 79,420 \div (127.5)^2 = 1.303 \times 10^6$.

Tabulating the above results and using 2O to express twice the amount of oxygen theoretically necessary to the reaction, and similarly 3O for thrice the theoretical oxygen, and 4O for four times the theoretical amount, we have per kilogram of explosive mixture:

	Net Heat of Reaction Calories	*V* Liters	*HV* x 10^6
Dynamite No. 1	1,170	536	0.627
Naphthaline-oxygen	2,246	612.5	1.375
Cellulose-oxygen	1,690	696	1.176
Carbon-oxygen	2,123	509	1.08
Carbon-oxygen + 10 per cent oxygen-carbon + 4O	1,973	522	1.03
	602	640	0.385
Aluminum-oxygen	3,653	nil	nil
Aluminum + 2O	2,455	224	0.549
Aluminum + 3O	1,840	342	0.629
Aluminum + 4O	1,463	409	0.599
Cartridge No. 5 (Cellulose-naphthaline)	.....	.....	1.309
Cartridge No. 6 (Cellulose-naphthaline-aluminum)	.....	.....	1.303
Cartridge No. 4 (Carbon-naphthaline-aluminum)	.....	.....	1.12
Cartridge No. 2 (Cellulose)	1,690	696	1.176
Cartridge No. 2A (Cellulose + 2O)	1,062	700	0.743
Cartridge No. 3 (Cellulose-aluminum)	.....	.....	1.015
Cartridge No. 1 (Carbon)	.....	.....	1.088

Naphthaline and Cellulose More Effective Than Carbon

From the above it is evident that the employment of additional oxygen for the purpose of increasing the gas volume is scarcely to be considered, but that, on the other hand, the gaseous vapor formed by the explosion of both naphthaline and cellulose is productive of high volume and the greatest *HV*. It is evident, although the carbon-oxygen product is stated to be superior to dynamite, that naphthaline and cellulose should be still more effective than carbon, and that these materials have possibilities of a high order. The preparation of "activated" carbon has already reached an advanced stage: it is suggested that the preparation of especially suitable cellulose may carry the efficiency of the process still further.

It is difficult to account for the use of aluminum in the Lorraine cartridges, unless the intense but gasless heat increases the wave speed and thus the impact or "brisance." It is to be hoped that the U. S. Bureau of Mines or some other body possessing adequate resources and appliances will investigate this question of wave speed and give us authoritative data for the various combustibles used, including "carbene."

The following table shows the different oxygen requirements of various combustibles. Cellulose shows up particularly favorably, having regard to its high *HV* and its low oxygen consumption.

Carbon: 1 g. requires 2.66 g. of oxygen; paper and wood pulp and cotton wool may be taken as cellulose ($C_{12}H_{20}O_{10}$).

Cellulose: 1 g. requires 1.19 g. oxygen.

Naphthaline ($C_{10}H_8$): 1 g. requires 3 g. of oxygen, the hydrogen being converted into aqueous vapor with great benefit to the reaction.

Aluminum: 1 g. requires 0.88 g. oxygen for its conversion into Al_2O_3.

Magnesium: 1 g. requires 0.67 g. oxygen, for its conversion into MgO.

Silicon: 1 g. requires 1.14 g. oxygen for its conversion into SiO_2.

Iron: 1 g. requires 0.43 g. oxygen for its conversion into Fe_2O_3.

Making Copper 600 Miles North of Vancouver*

Granby's Mining and Smelting Practice at Anyox and Its Position as to Concentration

By L. R. Clapp
Manager, Allenby Copper Co., Allenby, B. C.

AT ANYOX, B. C., the Granby Consolidated Mining, Smelting & Power Co. is mining and smelting directly in blast furnaces about 3,000 tons a day of a heavy pyritic copper ore, which carries perhaps 2 per cent of copper and 30 to 50c. per ton in gold and silver. To carry on this essential work, it also operates a water-power plant of about 10,000 kw. capacity with a 5,000-kw. auxiliary steam plant; it produces about 60,000 tons a year of coke from byproduct coke ovens, from which it also obtains and sells about 2,000,000 lb. a year of ammonia and ammonia salts, 500,000 gal. of tar, and 160,000 gal. of motor benzol; it operates an electric railway handling about 6,000 ton-miles of material each day; it has a well-equipped iron and brass foundry, extensive blacksmith, machine, boiler, car-repair, and carpenter shops, and a fully equipped sawmill, and it owns and administers the affairs of a modern industrial town of about 2,500 inhabitants, including the operation of a department store doing a business of about $700,000 a year.

Anyox is situated at the mouth of Hidden Creek, on Granby Bay, an excellent deep-water harbor at the head of Observatory Inlet, about 90 miles north from Prince Rupert and 600 miles from Vancouver, and is accessible to the outside world only by boat. Its location on tidewater has made the transportation of supplies and blister copper cheap but slow; and its isolation has made for a stability of labor conditions that is important, but, at the same time, has necessitated the carrying of exceedingly heavy supply stocks to avoid disastrous delays. The unfavorable climate, with excessive rain and snow, has induced the company, particularly in the earlier years of the plant, to go to unusual lengths in comfortably housing and adequately amusing its employees. As a result Anyox is an exceptionally comfortable town.

The smelter, coke plant, power plants, and shops are all situated at the beach, and the mine is perhaps a mile and a half further inland, at an elevation of about 400 ft. above sea level.

Ore Occurs Along Contact of Shale and Greenstone

The orebodies at Anyox are found in, and near, the contact of a crumpled and partly metamorphosed series of shales, known as the argillites, and an intrusive greenstone. These rocks, according to Dolmage, are both remnants of a complex series belonging to the Lower Jurassic, since surrounded by the granitics of the Coast Range batholith, from which it is supposed the mineralizing solutions have originated. The argillites are found in a roughly pear-shaped area about ten miles long and perhaps six wide, approximately centered upon Anyox, and contain quartz, biotite, sericite, with small amounts of pyrite, pyrrhotite, and carbonaceous matter, and occasional beds of sandstone and limestone. Near by the contact they are metamorphosed and in places completely silicified, merging into the equally silicified greenstone without definite contact. The greenstone lies to the west of this area and extends across the mountains to Portland Canal, perhaps eight miles away, and is regarded as younger than the argillites, and intrusive in them. The contact between the

*Read at the British Columbia meeting of the Canadian Institute of Mining and Metallurgy.

Granby Consolidated's smelter at Anyox, B. C. Site for new concentrator at right. Construction of mill has since been started (see front cover).

two, though irregular, has a general north-and-south trend and is exceedingly irregular as to dip.

The Hidden Creek deposits are of two classes: the first consists of a series of irregular lenses of heavy pyrite, with some copper, lying at a contact of the intrusive greenstone and the argillites, at a point where the contact sweeps around in a horseshoe-shaped embayment of the greenstone. These lenses were probably formed by solutions ascending along the contact and impounded under the overhanging curls in the argillite footwall, where a laccolithic spur of the greenstone has penetrated into the older rock. In general shape, they are not unlike pollywogs, with the head pointed upward against the overhanging argillite roof and the tail stringing off down the contact and feathering out into small isolated patches of ore. The cores of these lenses are usually of higher grade than the outside part. An ideal cross-section would show an envelope of silica surrounded by a varying band of low-grade pyrite, and in the center a core of higher-grade pyrite and chalcopyrite mixture. So marked is this feature that at least two very large bodies of sulphide have been encountered in which the core of commercial copper ore has been so small as to be hardly minable, although the bodies themselves contain several million tons.

The second type of deposit consists of chalcopyrite and pyrrhotite, occupying the joint planes and impregnating the rock, in shear zones in the greenstone. Those which have been so far uncovered lie close to the contact and have perhaps been formed under an impounding roof curtain of the argillites, which has since been eroded away. In the upper portions, which we may imagine lie close to this argillite roof curtain, the country rock has been considerably silicified, and this silicification gradually disappears as we descend from the surface. In both types of deposit silicification has apparently preceded ore deposition.

Cutting all the rocks of the district, and also the orebodies, are innumerable dikes of every variety from ultra basic to quartz porphyry. Some are hundreds of feet wide. In the vicinity of the orebodies over one hundred dikes have been identified and numbered. The inclosing rocks and the ore were not altered where they pass through and they have a marked tendency to avoid the heavy sulphide ore lenses. Some, unfortunately, do cut through the ore, and where they are large they complicate the mining. Dike rock in any amount cannot be treated in a pyritic blast furnace.

15,000,000 Tons in Seven Orebodies

Nearly 15,000,000 tons of ore has so far been developed in seven orebodies, of which over 13,000,000 tons has an average copper content of 2.14 per cent. The gold and silver values vary from about 12c. in No. 3 orebody, to 90c. per ton in No. 5. Chalcopyrite is the only copper mineral of consequence, and is intimately mixed with both pyrite and pyrrhotite. Zinc-blende and arsenopyrite are found in very small amounts.

Orebodies Nos. 2 and 3 are entirely in the greenstone, and appear to be the roots of an orebody once extending to the old argillite roof. No. 3 is a continuation of No. 2, a pre-mineral fault separating them. They form a thick vertical lens, 750 ft. long, 240 ft. thick, and with a known depth of 650 ft. The original depth was much greater, but the top has been eroded away. No. 6 orebody is west of No. 1 near the contact, but has the general characteristics of Nos. 2 and 3, being marked by high insoluble and high alumina, and lying almost entirely within the greenstone.

Orebodies Nos. 1, 4, and 5 are characterized by low insoluble and high sulphur, and form a zone extending for about 1,800 ft. along the southern and eastern curved margin of the greenstone, but largely in the argillite. Ore is found in it 900 ft. above sea level, and 500 ft. below. The zone is in reality an overlapping succession, both vertically and horizontally, of lenses of sulphide ore, filling the tucks in the argillites. Between the lenses are ribs of varying widths of silicified argillite, usually well enough mineralized to pass as ore. No. 1 orebody, as now known, is made up of no less than eight lenses, and in No. 5 there are three known lenses. With depth more may be expected. The individual lenses vary greatly in volume, the largest containing about 1,000,000 tons.

No. 4 orebody runs low in copper and high in sulphur, and the ore is sold for making sulphuric acid. It lies above the bulge of the greenstone, so has an easterly dip, whereas No. 5 is below No. 4 and under the bulge, and has a westerly dip. The lenses of No. 1 orebody wrap the bulge.

The Bonanza orebody, south of Anyox, is tabular, with a low dip to the north. The footwall is a greenstone-amphibolite (somewhat different from that at Hidden Creek), and the hanging wall argillite. The greenstone is part of a projecting mass, smaller than that to the north, but similar. About 20 per cent of the volume of the orebody is dike rock, and it contains approximately 300,000 tons of an average grade of 2.49 per cent copper, including dikes. Its comparatively thin section, combined with its flat dip and large amount of dike, does not make it an attractive mining possibility at present. If it can be concentrated, with the removal of the dike material, its future will look somewhat brighter.

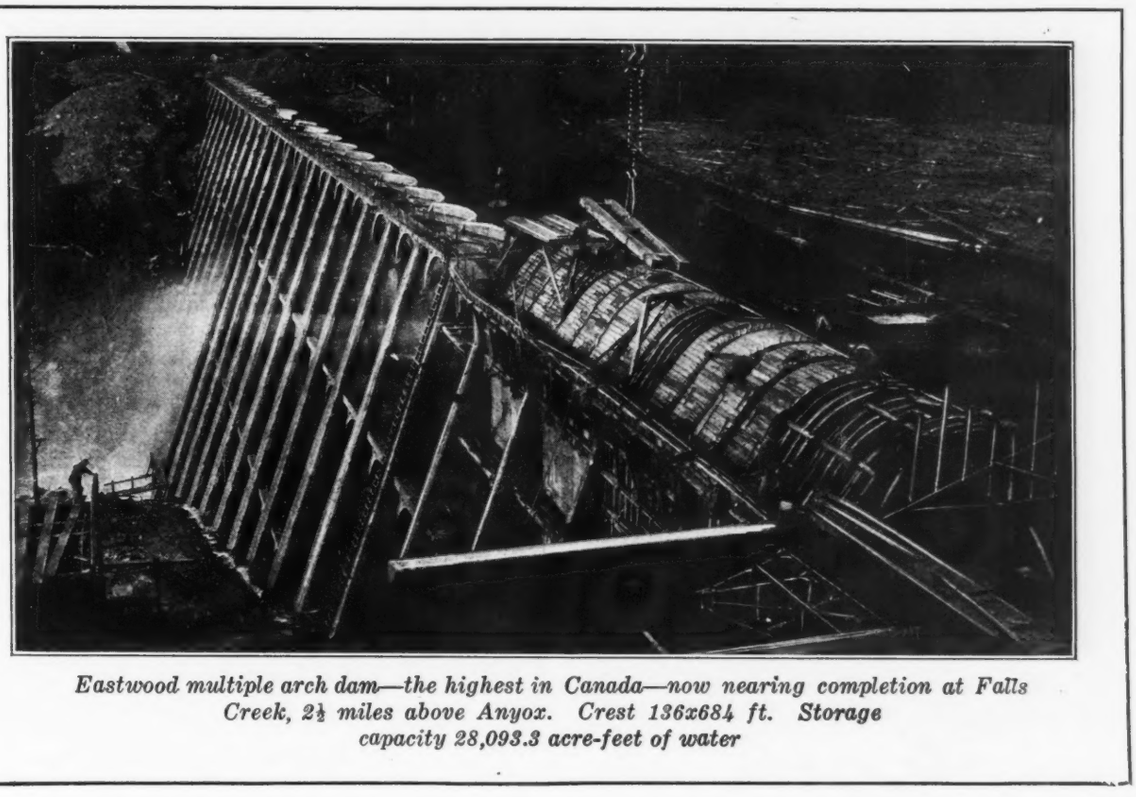
Prospecting Largely With Diamond Drill

Only three of the seven orebodies so far developed showed any considerable outcrop on the surface. The others have been encountered by diamond drilling and lie, usually, under an overhanging curtain of argillites. Practically all the prospecting for a new ore, and also the laying out of development work, is done with the diamond drill, and a total of about 27 miles of diamond-drill cores have been made to date. The rock conditions are favorable for this type of work. Drilling is slow, on account of the extreme hardness of the silicified portions of the orebodies, but coring is most satisfactory, and it is seldom that 100 per cent cores for the footage drill are not obtainable. The work is all done on contract by a firm of diamond-drill men from Spokane, and over-all costs average from $2 to $2.50 per foot.

Core records have been carefully preserved, and, when assays are made, the core is carefully split longitudinally, one-half being ground up for assay pulp and the other half preserved for geological record. In this way a complete and easily available record is kept of practically every hole that has been drilled on the property since the start. The assay samples are divided into 5-ft. intervals through the ore zones, and the assays for holes may be checked against a composite sample, on which the copper is determined electrolytically.

It has been our experience that it is never safe to assume that a diamond-drill hole will run in the direc-

tion in which it has been started. No matter whether a hole is vertical, flat, or inclined, it always deviates from its original course by an amount dependent on the angle with the rock structure at which the hole is drilled, by the effect of gravity on the drill rod, the presence of faults, slips, and hard patches. We have found that the only dependable method is to survey each hole (usually at 100-ft. intervals) before attempting to plot it on our geological maps. For this we use a small drill-hole compass floating in warm gelatine in a glass tube and attached to several lengths of brass drill rod, which is lowered to the desired point in the hole, and allowed to remain there until the gelatine cools and solidifies, thus fixing the position of the compass needle. The inclination of a hole is taken, at the same time, by the usual hydrofluoric acid ring in the same glass tube.



Eastwood multiple arch dam—the highest in Canada—now nearing completion at Falls Creek, 2½ miles above Anyox. Crest 136x684 ft. Storage capacity 28,093.3 acre-feet of water

Electrical Prospecting Experimented With

Recently we have been much interested in the possibilities of electrical prospecting with a potentiometer. This device consists of a delicate galvanometer and two or more electrodes with suitable lead wires by means of which the conductivity of a rock mass may be measured and compared with that of other masses. By plotting equipotential curves on the surface of the ground, it is claimed to be possible to outline an orebody, particularly one with heavy metallic mineralization, even when buried under several hundred feet of barren overburden. We tried it out first on an orebody previously outlined by the diamond drill and obtained surprisingly accurate results. Later, when we attempted to go farther afield, we found that the presence of dikes so affected our readings as to render the results valueless. Apparently, our galvanometer is too delicate, and some means will have to be found to damp out the influence of basic intrusives; but the method may prove of considerable value on some orebodies as a preliminary.

The mine has been opened up on seven levels, varying from 100 ft. to nearly 250 ft. apart vertically. These all have outlet to the surface except the two lowermost. Originally much of the drifting and raising was prospective in nature, but since the accumulation of the large amount of diamond-drill data, the location and direction of all levels, drifts, raises, crosscuts, and other workings is determined in advance on the basis of the geological maps; and in this way much lost motion is avoided. The orebodies vary from 50 to 350 ft. in width and from 300 to nearly 2,000 ft. in length, and are developed on each level by parallel drifts, perhaps 50 ft. apart, which run along the axis of the orebody.

The main haulage levels are all developed on 36-in. gage track and are equipped with the familiar Granby automatic side-dump type cars of six to ten tons' capacity, with electric locomotive haulage and complete block-signal system. The electric railway connecting the mine with the smelter is also 36-in. gage.

The ore is all hauled out the level at 385-ft. elevation and passed through one of three 30x42-in. Farrell-Blake crushers, which are mounted at the surface, with large underground storage pockets beneath them leading down to the 150 level below. All ore from below the 385 level is hoisted through a vertical four-compartment shaft, or winze, which extends from the 530 level to below the 130 level (all level numbers refer to elevations above or below sea level), and is equipped with a 250-hp. double-drum electric hoist, operating two eight-ton skips in balance.

Up to the present year the tonnage hoisted was a comparatively small part of the total, but with the approaching exhaustion of the upper levels of the orebodies, we are almost completely dependent upon the shaft for our tonnage and are now installing a 500-hp. double-drum Vulcan electric hoist, with all the latest operating and control devices, to insure better continu-

ity of operation, leaving the smaller hoist to handle the cage and the men. The skips, which will be increased to ten-ton capacity with the heavier hoist, are served by a series of three loading pockets leading into a common chute with air-operated finger gates. Below the 150 level there is no access to the surface, and the levels are opened with 24-in. gage track. The zero level has about one and one-quarter million tons tributary to it and the 130 level, about three-quarters of a million. Unless diamond-drill work shall uncover more orebodies, it seems improbable that further development in depth will be done. From our present information, the ore fingers out into scattered bunches in the slates below this horizon, and does not at present seem profitable.

Actual mining is being done on two general systems: one, the familiar method of shrinkage stoping, where, in

Glory-hole, No. 1 orebody, Hidden Creek mine, Anyox, B. C.

a given area, the stoping is carried up on broken ore, only sufficient being drawn out each day to permit the men to work, until the stope is completed up to the next level. There are two points regarding this method which I believe are peculiar to Anyox practice; one is the size of the stopes which have been carried on this system. A large shrinkage stope in No. 2 orebody is approximately 350 ft. long by 150 ft. wide and was carried up nearly 200 ft. No timbering of any kind was used in it, and there was, I believe, but one fatality during the course of its operation. The other point in connection with the method, which I believe is peculiarly Anyox practice, is the system of bulldozing chambers above the chutes. In all our stoping no timbering is used in the drifts other than for the chute mouths. We leave a block of ore over the drift, from 15 to 30 ft. thick, before actual widening out of the chute raises is begun. Between each two chute raises, before the stope is under way, is put up a small manway raise, perhaps 20 ft. high, with two small crooked drifts leading from the top of it to the two chutes. Here chambers are cut out and used for block holing and bulldozing. As the broken ore is drawn down in the chute, the large boulders are uncovered in this chamber and can be reached with a jackhammer and broken up. In this way we avoid blasting in the chutes themselves, with the attendant dangers on the level and the wear and tear on the chute timbering. The bulldozing drifts are made crooked so that when the block holer has spit his fuse in one chamber he does not need to go down to the level but can move over into the other one until his blasts have gone off.

Mining Chiefly by Underground Glory Holing

The bulk of the mining at Anyox, however, has been done by a system of underground glory holing, brought to the Granby company in the old days from the Michigan iron country by W. Y. Williams and the Swanson brothers, who modified it to the local Phoenix conditions and improved it. This work was later transferred to Anyox by John Swanson, our present mine superintendent, and has been perfected by him there until it is a highly economical and safe method of mining large, hard orebodies. It consists essentially of spiral raises which are started off from the top of the chute raises and swing around on a grade which is just flat enough to permit a man to walk up the trail. When complete, this first raise resembles nothing so much as the impression left by a corkscrew, with a hollow core and the spiral trail left around the outside of it from the bottom to the top. At the extremities of the swings of this spiral trail, connections are made to manway raises, driven through the pillars at either end of the stope, to afford ventilation and easy access for powder and steel. Upon completion of the first spiral, depending on the nature of the ground, either a second spiral is started, interlacing the first, or the first spiral is gradually enlarged, breaking always to the center and benching off, when desirable, the shelves between the grooves in the spiral. The stope is drawn empty each day, and the fall down the irregular chute acts, to a considerable extent, as a rock crusher for the large slabs which are broken off. When necessary, a rib of the spiral can be left as a strut across the stope to support some heavy ground, and this is usually drilled, and later some means are found to reach it and blast it down.

Glory Holing Has Many Advantages

The method has many advantages; among which should be noted safety, lack of timber, and easy breakage. The miner is always working under an overhanging shelf of rock and has no occasion to go out into the middle of the stope where he might be hit by falling ground. Access to the manways is always easy. By going around one side of the stope or the other on the spiral trail, one manway or the other can be reached quickly. No timber whatever is used above the chute mouth except for the ladders and skids in the manway. Flexibility of the method is another point in its favor. When lean ground or a dike is encountered, it can usually be left as a pillar and taken down at some time later after the ore has been removed. No appreciable

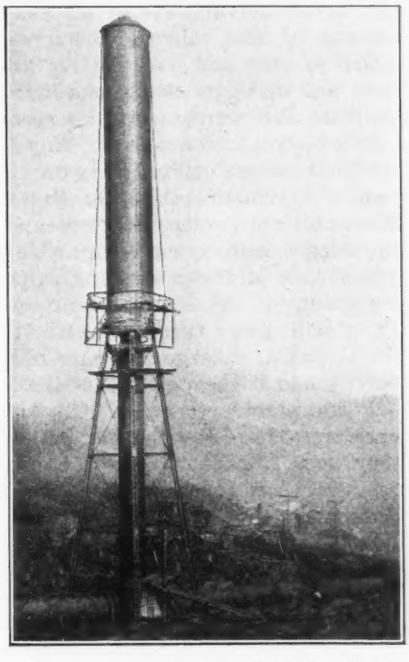
amount of money is tied up in the broken ore in the stope, and mining can be transferred from one part of the stope to another, or from the bottom to the top, to change the grade or composition of the ore supply. This is particularly important at Anyox, as the mine is, in reality, a mixing plant for the furnaces, and the control in the mine of the chemical composition of the ore is absolutely essential for successful operation.

Costs of this method for 1922 have averaged about 48c. a ton, and tons per miner's shift have averaged from 150, in the older stopes and the glory holes, to twenty in newly opened stope raises.

The ore is, as I have said before, extremely hard, and breaks in large slabby masses. A great deal of block holing is necessary, and indeed the secondary breaking is nearly as large an item of expense as the primary. These are, however, both included in the costs given above. The ore is drawn through the chutes into the Granby-type ten-ton cars and transported to the crusher bins, where, with a certain amount of further block holing, it is gotten into the crushers and there reduced to about 10-in. size.

Three Classes of Ore Broken

There are three classes of ore broken in the mine: No. 1 ore, being heavy sulphide, is by far the heaviest tonnage; the greenstone pyrrhotite ore is second in amount; and the low-grade siliceous envelopes surrounding the orebodies, used to some extent as a flux, make up the total. Each class of ore is kept separate through the crushers and down to the smelter. Each crusher is served by two feed pockets, and has under it two discharge pockets. As the ore passes through the crusher there is an automatic sampler which cuts out a small proportion of the stream and deposits it in a third pocket. In this way the lots of ore are kept separate. The crusher man will draw out of one feed pocket until it is empty and hold the crushed product in one of his lower pockets until the sample (which usually amounts to twenty-five or thirty tons), is taken down to the smelter, crushed, and analyzed; then the pocket is drawn and the second lot made up. In this way the smelter has, at least theoretically, advance information as to the character of the ore which it is receiving. Delivery to the smelter is made in twenty-five-ton hopper-bottom cars, hauled by forty-two-ton electric locomotives, and the ore is dumped into a series of storage bins, with a total capacity of perhaps 4,000 tons. From these the various charges are made up.



Larner surge tank, 172 ft. high and 12 ft. in diameter, straddling 6-ft. wood-stave power line

Glory-hole workings, Hidden Creek mine, Anyox, B. C.

The mining department, in addition to the main operations, also runs a small silica quarry, from which a certain amount of barren quartz is mined, for use in the final converting operation.

Formerly the company also conducted its own limestone quarry at Swamp Point, on Portland Canal, but the supply of limestone here became difficult to obtain and purchase is now made from the Pacific Lime Co. in Blubber Bay and transported to the plant in 1,500-ton scows.

Air Requirements Heavy

The mine is served by four air compressors erected at the beach, with a mile and a half of 10-in. air line connecting them. One of these compressors is a 3,500-ft. Nordberg, direct-connected to a Pelton water wheel, and two others are inheritances from Phoenix; one of 5,000 ft. and the other 2,500 ft. capacity, both operating by rope drives and still giving excellent service after fifteen to twenty years of operation. We have recently purchased a fourth machine, a Chicago Pneumatic Tool, 3,500 ft., direct-connected to a synchronous motor, partly for stand-by service and partly for power-factor correction. A great deal of air is used, not only for drilling, but for small hoists, sharpening machines, chute gates, small pumps, and the like through the mine; and though under ordinary conditions any two of the compressors should handle the load, our rather heavy program of development work now under way has made it almost imperative to supply at least 6,000 ft. of air per minute.

Smelting at Anyox Semi-pyritic

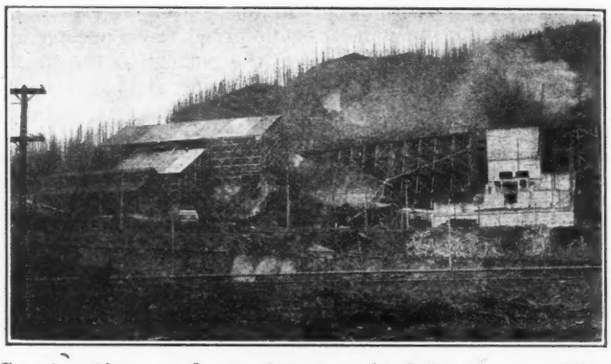
Semi-pyritic smelting, such as is conducted at Anyox, in contradistinction to standard reduction smelting, is strictly an oxidation process. Chemically it is identical with the operations in a converter when matte is blown up to blister, although it is conducted in a different vessel, and continuously, with the duty of liquefying the charge added to the usual one of oxidizing and slagging the iron. If you consider the heavy sulphide ore as a cold, low-grade matte, and the remainder of the charge as a siliceous flux for slagging the iron, with the coke present only to drive off the moisture and help the furnace over the rough places, you will have a clear conception of the fundamentals of the process. The chief governing factor is the blast, and that is used in amounts greatly in excess of the requirements of

reduction smelting. At Anyox between 26,000 and 32,000 cu.ft. of air per minute is pumped through each furnace, or the equivalent of 215 ft. free air per minute per square foot of hearth area. Other things being equal, the speed of the furnace and the composition of the slag are directly dependent upon the amount of air blown through. The greater the air, the more iron is oxidized, the more slag is formed, the more heat is generated, and the higher grade is the matte. This, of course, has its limitations—in the amount of air that can be forced through the ore column without excessive back pressure and in the height of the ore column necessary to absorb the heat rising from the zone of intense reaction above the tuyères. Strangely enough, the sulphur in the ore plays very little part in the generation of the heat. The greater part of it is distilled off in the upper part of the ore column and burns only on reaching the top and coming in contact with the outside air. Even that which is carried down toward the focus and combines there with oxygen is immediately robbed, in its ascent through the ore column, by the incandescent coke.

Ideally, a cross-section of a pyritic furnace in operation will show a column of incandescent silica fragments over which trickle streams of molten sulphide exposed to the scorifying action of the high-velocity blast, which oxidizes the iron on the surface with the evolution of a considerable amount of heat. This ferrous oxide immediately combines with the nearest silica. with a further generation of heat, forming slag, which

Converter floor at Granby smelter. Five Great Falls type converters (three 12 ft. and two 20 ft. in diameter), served by three 40-ton cranes

drips down toward the hearth, picking up on its way more silica, or lime, depending on the local temperature. The sulphide continues down, losing iron continuously, until it drops through the slot in the jacket crusts above the tuyères and into the bath below. Its copper content will depend upon how much air was



Construction work at Anyox. At left, the crushing plant. At right, the 1,000-ton milling unit and Dorr thickener plant

blowing through the channel down which it passed, and the amount of clean quartz it encountered on the way.

The thermal balance of a pyritic furnace, even under ideal conditions, will show only a small excess of heat over the amount necessary to drive off the contained moisture, decompose the limestone, and melt the charge, with the necessary losses in radiation, jacket water, and stack gases. In commercial operation, the introduction of any unusual amount of dike rock, or other combined silicates, or even an excessive amount of fines in the ore, will completely upset the balance and the furnace will freeze up. Though we have run a furnace for periods of thirty days or more without any coke whatever, the operation is too delicate and we normally add from 4 to 6 per cent of coke as thermal insurance.

Furnace Campaign from Ten to Forty Days

Smelting at Anyox is a matter of tonnage. Each of the four furnaces under proper conditions will put through about 800 tons of original ore each twenty-four hours (a duty of 6.03 tons per square foot of hearth area per day), and matters of metallurgical refinement in the way of close balance of charges to furnaces, composition of slag and like matters are unknown. A furnace will make its own composition of slag, depending on blast and temperature, irrespective of the furnaceman's desires in the matter. Any portion of the charge which it cannot utilize in its own self-chosen combination will remain behind in the furnace as a crust. Whenever the furnace is temporarily out of metallurgical balance, some crust is formed, and as it is not in the direct path of the descending sulphides, there is nothing to flux it out, and it remains and grows. Eventually it will close a furnace down. It can be fluxed out by the addition of large amounts of coke and limestone, but we find it cheaper to shut the furnace down, dig it out, and start over again. By long practice our furnace crews have reached that stage of perfection where they can blow out a furnace, dig it, repair jackets, reassemble, and have a charge on it again in twenty-four hours. A furnace campaign lasts from ten to forty days, and no attempt is made to prolong its life after the tonnage begins to fall. Any furnace which fails to make 600 tons of new ore in twenty-four hours is, to use a furnaceman's expression, given the hose—that is, tapped out and the hose turned on it to chill and crack up the crust and facilitate digging.

The ore is drawn out of the railroad bins in the usual Granby-type cars in proportions of, say, six parts of heavy sulphide ore to two parts of pyrrhotite greenstone

ore and one of siliceous envelope. To this is added about 5 per cent of dry coke and a small amount of limestone, and the material is dumped into charging hoppers on both sides of the furnaces. From here it is fed into the furnaces, as need arises, by an air-actuated ram which pushes the ore gently, or violently, as the circumstances demand, over the edge and into the shaft. Furnaces are not charged at any set times, but the ore is fed at various points as the surface of the ore column indicates, and the need for blocking up blow holes and so forth develops. Unlike reduction plants, the furnaces run with very hot tops, with a swirling flame of burning sulphur and decrepitating particles of pyrite dust covering the ore column.

Converter Flux Fed Mechanically

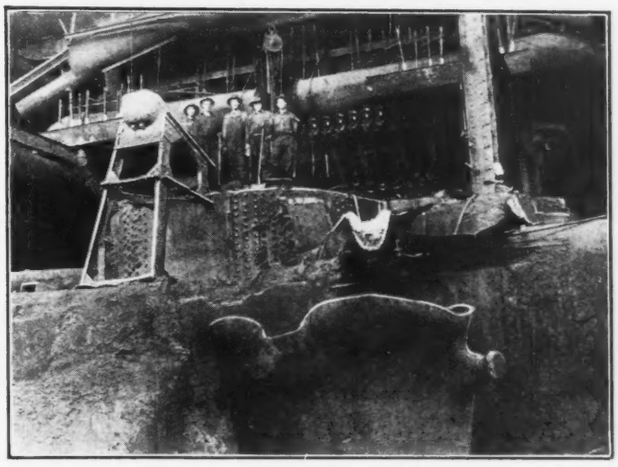
Matte and slag are drawn off continuously through a jacketed spout into a series of forehearths or settlers, the final slag overflow being granulated at the spout and washed out to the dump in slag-lined launders. From these settlers matte is tapped intermittently into cast-steel ladles and delivered by the crane to a battery of five converters; two 20-ft. Great Falls type and three of the smaller 12-ft. style, all made by the Traylor company. These converters are all basic-lined, and flux is added from time to time as the condition of the blow indicates. Recently we have been experimenting with roller or plunger flux feeders so designed that they will feed a small stream of flux continuously through the mouth of the converter during the blow, in this way avoiding dangers of matte explosions from the introduction of wet flux, and insuring a more continuous operation. These have been eminently successful metallurgically. The only difficulty we have encountered has been of a mechanical nature, with the ironwork of the feeders exposed to the heat and gases above the mouths of the converters. This, I believe, we can overcome, but, in any event, the advantages of the method are sufficient to compensate for any maintenance difficulties.

Economical to Make Low-Grade Matte

The furnace matte will run approximately 15 per cent copper—which is extremely low from a reduction smelting point of view, but is economical for our particular conditions. By the addition of a cleaner siliceous ore in the blast furnaces, and by higher blast pressure and a higher ore column, we would be able perhaps to approach Mr. Sticht's record in Tasmania, where he was able to produce a 45 per cent matte with a clean pyritic ore and highly siliceous flux, but our Hidden Creek silica contains a considerable quantity of combined silicates, which furnish no heat of reaction, but, on the contrary, absorb heat from the charge and make a sticky, viscous slag, and we cannot obtain the pressure necessary to increase the oxidation without scrapping our blower equipment. A small part of the matte we break up and send through the furnaces again, and we believe that it acts as a lubricant and equalizer to the charge. The greater bulk of it, however, we send directly to the converters, as we find that regrading in a converter is cheaper than regrading from the blast furnace. We bring the grade of the matte from 15 per cent to perhaps 35 per cent in the two large 20-ft. converters, and then transfer to the 12-ft. machines for the finishing blow. We finally pour an excellent blister of from 99 per cent to 99.10 per cent copper.

Our fluxing practice in the converting operation is worthy of note. We have found that by the addition to the bath of certain minerals of the ferromagnesium group, as occur in some of our greenstone ores, we form artificial spinels, oxides of magnesium, manganese, zinc, iron, and aluminum—a sticky, partly fused mass which adheres to the magnesite brick lining of the converters and forms a non-corrosive coating therefor, greatly prolonging its life. Further, the formation of these spinels in the bath absorbs considerable heat, holding the temperature down to a reasonable point while permitting long, continuous blows, even with our high iron mattes. If we should add a straight quartz flux to our first-stage operation we would burn out our lining in short order and raise our bath to such a temperature that the converter would have to be turned down from time to time to allow it to cool. As it is, we can blow a 15 per cent matte continuously without danger of overheating or excessive corrosion.

Our converter slag, contrary to usual practice, we pour back into the blast-furnace settlers. We have found that if we do this just after the matte has been tapped, and before the settler has filled again, there is sufficient time for the low-grade matte to react with the slag and clean out the prills and shots of the copper almost completely before the overflow again starts. Test runs, over several months' time, have shown less than .01 difference in our slag copper assay when pouring converter slag, compared with furnace slag alone. There is no doubt that the large settling areas, high temperatures of the matte, and its low copper content all contribute to making this operation possible. It is a convenient solution to a usually difficult problem. A small part of the converter slag we granulate and use as a binder in our flue-dust sintering operations. For this it serves excellently, giving enough porosity to the bed to permit the blast to pass and serving as a good glue to hold the sintering mass together.



Traylor furnace and settler at Granby smelter, Anyox

Breast jackets, matte-tapping blocks for the settlers, and molds for the blister copper-casting machine are all poured in the converter room from our own blister, with the addition of a small amount of manganese or phosphorus, as a scavenger. Furnace jackets, bustle pipes, tuyères, spouts, and charging rams are all made in our own shops.

Last year we treated 876,000 tons of ore containing 34,500,000 lb. of copper, and produced 29,280,000 lb. of

blister at a total smelting and converting cost of $2.10 per ton, or 6.04c. per pound of copper.

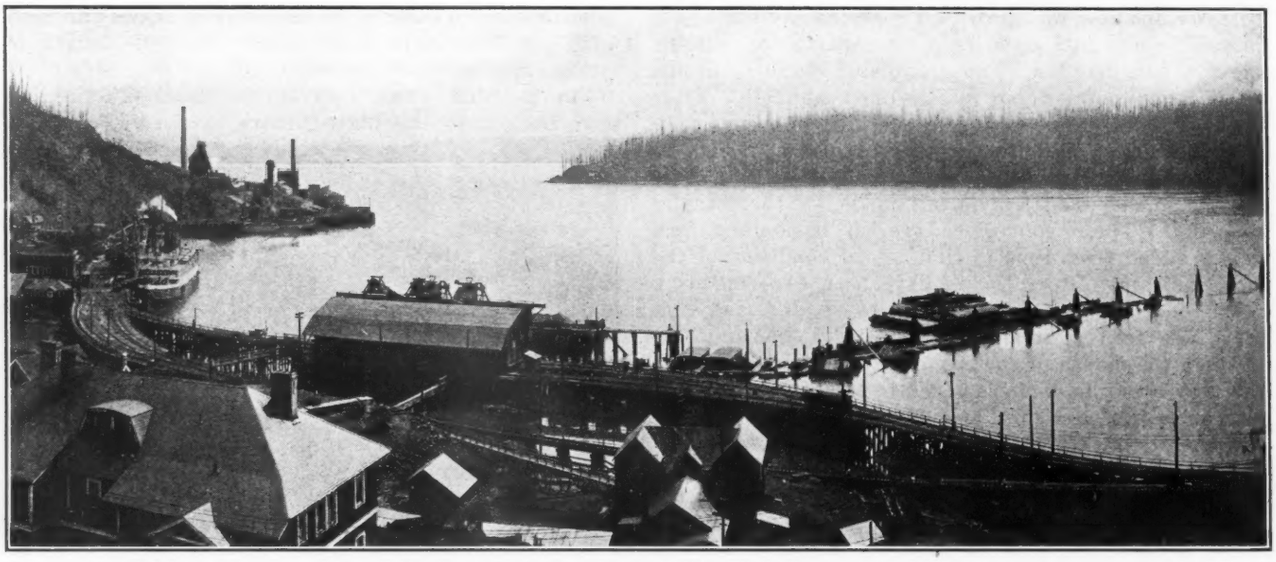
We produce about 100 tons a day of flue dust, which we catch in one of the ordinary old-fashioned rectangular flue chambers with the usual hopper bottoms, and we are sintering this on a standard Dwight-Lloyd machine, mixed with 10 to 15 per cent of granulated converter slag, to act as a porous binder. We have a considerable loss of flue dust through the stack, and have considered various methods of recovering it. The installation of a Cottrell precipitator is not justified with our low-grade material, and until we get into the smelting of concentrates the economics of the situation hold us to our present practice.

Anyox was originally opened on the metallurgical

Experimental work was undertaken with the idea of concentrating the greenstone ore and dropping out the undesirable silicate gangue. A typical analysis of this material will show:

	Cu	Insol.	SiO_2	Fe	CaO	S	Al_2O_3	MgO
Per Cent..	1.85	42.25	35	24	4	16	9	5

Obviously, a concentration operation that would remove only the silicate minerals would not be sufficient, as the cost of grinding, plus the added smelting cost of the ground material, would more than offset the slightly smaller tonnage smelted. Much of the iron in the ore was in the form of pyrrhotite, and, after some work, a method of differential flotation was worked out whereby pyrrhotite, which contained no valuable minerals, could be discarded with the silicates and we could expect a



Harbor entrance at Anyox, B.C., showing Granby's coke and byproduct plant beyond wharf at left

hypothesis that there were approximately equal quantities of the heavy pyrite and the greenstone orebodies, and that these were supplements of each other, so that when mixed with the proper quantity of coke and a little limestone they would smelt economically in the proportions in which they were found. Unfortunately, this did not prove to be the fact in actual practice. Much of the silica in both ores was found to be already combined with the alkalies, the alkaline earths, and alumina, and was not available in the furnace for the purpose of slagging the iron. Further, the unavoidable inclusion of dike material and the gradual disappearance of the free silica in the greenstone ore, as the mine grew deeper, made matters worse, until it was not possible to get even a fair pyritic effect, and it became necessary to use considerable limestone and coke and even barren quartz to keep the furnaces in operation. This made smelting operations expensive, and it was not until the proportion of the greenstone orebodies was cut down and replaced by some of the low-grade siliceous envelope of the pyritic orebodies that any cheap copper began to be made. This, however, introduced the complication that the heavy pyrite orebodies were being used up much faster than the greenstone orebodies, and would soon be exhausted, leaving untreated several million tons of greenstone ores which were by themselves economically unsmeltable.

concentration of this ore on something like 8 into 1, with a fair recovery.

A pilot mill was erected at Anyox and 40,000 or 50,000 tons of ore was put through it, definitely proving the possibilities of this method on a commercial scale. On the basis of these results, the preliminary design of a 1,000-ton mill unit was undertaken. Later we sent some laboratory samples to our friends of the Consolidated Mining & Smelting Co. at Trail, and they were able by the use of different reagents to discard not only the pyrrhotite in the ore but the pyrite as well, and to make a high-grade chalcopyrite concentrate that would be cheap and economical to smelt, owing to its relatively small bulk. If this is possible, it is conceivable that we might be able to take not only our greenstone ores but even our heavy sulphides, and, instead of putting them through the blast furnace, send them to the concentrating mill and make perhaps a 20 per cent concentrate, with a loss of not over 4 or 5 lb. per ton.

Now Seeking Method of Treating Flotation Concentrates in Present Plant

If there were tonnages enough to justify the installation, and if the subsequent smelting of the concentrates should not prove too expensive, our present system of direct smelting would then be obsolete, and Anyox would become a camp of concentrating mills and reverberatory furnaces. Unfortunately, the problem is not

so simple. Our present known tonnage will hardly justify the cost of a reverberatory plant, and we have a number of custom-ore shippers whose product could not well be handled with the reverberatories. Unless, then, we can find some cheap method of smelting flotation concentrates with our present equipment, we must continue to treat at least a portion of our tonnage by pyritic smelting.

There may be some way that flotation concentrates can be handled advantageously in a blast furnace. Several methods have been suggested and are under consideration. The first, that of mixing the concentrate with the flue dust and sintering it on the Dwight-Lloyd machine, is simple but expensive, and would probably entail some sort of Cottrell treater for the sintering plant as well as for the blast furnaces. A second possibility involves the blowing of the dried concentrate through either the blast furnaces or the converter tuyères, which is metallurgically sound, but, I fear, mechanically weak. A third involves the feeding of the concentrates directly into the mouth of the converters in the same manner as siliceous flux is now fed, accepting a certain high dust loss, which would be caught in the dust chamber and by Cottrells. This would presuppose sufficient molten matte coming from the blast furnaces to liquefy the flotation concentrates, or the concentrates can be fused in an electric furnace before adding to the converters. Another scheme, and perhaps the wildest of the lot, has been to mix them with a certain amount of coal and make coke from the mixture in our regular byproduct coke ovens. Results from experimental work on this have been excellent so far as the resulting coke product is concerned. It takes on the consistency of carborundum and stands ill-usage excellently. The only difficulty of the scheme so far found is that, to make a proper mixture, it takes almost twice as much coke as concentrate. In other words, if our ore were all reduced to flotation concentrates, we would have to run on a 200 per cent coke ratio. All these schemes are being investigated, and it may be that a way can be found to handle flotation concentrates in a blast furnace as cheaply and as effectively as low-grade ore. If so, we can either mine our orebodies at a considerably higher rate of speed or we will have a large amount of excess smelting capacity for custom ores.

First Unit of Mill Now Being Built

We are now erecting the first 1,000-ton unit of our concentrating mill, and it will be in operation soon after the first of the year. In it we will treat our excess greenstone ore and certain portions of the siliceous material surrounding our other orebodies. We will also try out the preferential flotation of our heavy sulphides with a view to perhaps treating at least the fine material which gives us considerable trouble in the blast furnaces. As need arises, the mill capacity can be increased to 2,000 or 3,000 tons.

For nearly twenty-five years the Granby company has been smelting its own copper ores, and has had an honorable metallurgical history. From the days of Phoenix and Grand Forks, where it was able to make a profit on the direct smelting of a 1 per cent ore, to the present at Anyox, where it is operating the largest pyritic smelter in the world, Granby has been, in the mining camp slang, a company of gas-eaters. But times are changing: flotation and wet methods generally are gradually crowding in on the field of the dry metallurgy. We have taken our first step in that direction. We are becoming, as it were, amphibious. Who can tell but that in ten years more we may change ourselves from gas-eaters to web-foots and our totem from the salamander to the duck? That is on the knees of the gods.

Photo by A. A. Lease

Amalgamating plate floor of the Homestake Mining Co's. South Mill at Lead, S. D.

The plates are made of copper which has been plated with 2 oz. of silver per square foot. Each plate is 9x12 ft. in size. Twenty-four plates are fed by the 120 stamps in the mill.

Marketing of Cobalt Ores and Metal

Canadian Output the Most Important North American Supply

By G. C. Bateman
General Manager, La Rose Mines, Ltd., Cobalt, Ontario

COBALT is not one of the common minerals. Its distribution as a constituent of the earth's crust is limited, and its concentration into orebodies which can be commercially exploited is of comparatively rare occurrence. Although used in different industries, it is not found in a natural state which permits it being utilized without first having been converted into the metal or its oxides.

The largest market for the metal at the present time, as in the past, is in the ceramic industry, where it is extensively used for glazing and coloring. The deep blue of expensive china and stained-glass windows is derived from cobalt, and the clear white color is also due to the addition of a small percentage of cobalt. The metal is also alloyed with chromium and tungsten to form an alloy called stellite, which is used to replace high-speed steel for cutting tools. Stellite cannot be forged, but is cast and can be welded to steel. It was used extensively during the war, particularly in the machining of shells, where its properties of being able to work at high temperature and to take a deeper cut at higher speeds than tool steels made it a satisfactory substitute, notwithstanding its much higher price. Cobalt is also used in various forms in the steel trade, particularly for increasing the red-hot hardness of steel, increasing the magnetic qualities of steel, and in the manufacture of stainless steel. It is used, to a limited extent, for cobalt plating, as a substitute for nickel plating, and is finding an increasing market as a drier for varnishes.

Northern Ontario Supplies Large Quantities of Cobalt

The principal occurrence of cobalt ores on the American continent is in northern Ontario, where they are generally found associated with rich silver ores. Cobalt is also a constituent of the nickel-copper ores of the Sudbury district, and a small recovery was reported from this source from 1892 to 1894. The percentage, however, is very small and does not now constitute an available source of supply. A small deposit carrying gold is known in British Columbia, small occurrences are reported in the eastern United States, and there are extensive deposits in Missouri, where the ores are associated with lead, copper, and small quantities of nickel. The latter deposits, however, are low grade and are not being worked at present. The only cobalt ores now being marketed in America come from the cobalt district of northern Ontario.

In Europe and Asia an important source of supply has been from the silver-cobalt mines of Saxony, which have been worked for more than 400 years. Supplies from these mines, however, are now small, and ore must be imported. Prior to the discovery of the northern Ontario deposits, the major part of the world's supply came from New Caledonia, the French penal settlement, but production from that source is now also small. A new deposit has recently been found in Australia, the ores of which are remarkably high grade, running up to 25 per cent cobalt metal, and containing only a small percentage of nickel. These ores are being shipped to England. There are also important sources of supply in Africa, owned by the Tanganyika Copper Co., which is preparing to turn out the finished products. At the present time, however, the output from the Ontario mines practically controls the world's market.

During the six months ending June 30, 1923, the production of cobalt metal and its oxides in Ontario is reported by the Canadian Government as follows:

	Pounds	Value
Cobalt—metallic	139,746	$374,425
Cobalt—oxide	242,604	475,681
Cobalt—nickel oxides (unseparated)	265,379	152,852

It is difficult to obtain figures on the annual consumption of ores, but the consumption of cobalt metal, cobalt oxides, and cobalt salts, expressed in terms of cobalt metal, is 1,000 to 1,500 tons a year.

Cobalt Ores Generally Complex

Cobalt is not found in the native form, and is associated with other minerals, which make its treatment complicated and expensive. It is most commonly found as smaltite, an arsenide of cobalt, and as cobaltite, a sulpharsenide of cobalt. Both smaltite and cobaltite are generally associated with chloanthite, which is a nickel arsenide. Where there has been opportunity for the veins to weather, there is a certain amount of alteration to erythrite, an arsenical hydrous oxide of cobalt, known as cobalt bloom, and distinguished by its bright pink color, but it is not found in commercial quantities. Usually other cobalt minerals are associated with smaltite, but they are not important.

The marketability of cobalt ores depends not only upon the grade, but upon the other associated minerals. Arsenic is an important and desirable constituent of the ore, but the higher the nickel content, the less desirable the ore is, as the nickel must be separated and the expense is generally greater than the value of the metal recovered. This applies to practically all associated minerals, with the exception of arsenic and silver. On this continent it is almost impossible to market an ore for cobalt if such ore contains any considerable quantities of lead, zinc, and copper. An ore containing less than 4 per cent of metallic cobalt is not acceptable to the smelters.

Cobalt ore is being marketed in America in four different forms:

1. Hand-sorted silver ore and sand-table concentrates, carrying high silver values and running generally between 5 and 8 per cent metallic cobalt.

2. Massive cobalt ore carrying low silver values and running between 6 and 12 per cent metallic cobalt. Ores of this sort contain approximately 60 per cent arsenic.

3. Residues from the cyanide treatment of high-grade silver ores and concentrates, carrying 5 to 8 per cent cobalt, and up to 50 oz. of silver.

4. Speiss from American smelters treating silver-

cobalt ores and generally containing large percentages of iron, copper, and lead.

Flotation concentrates from the milling of silver-cobalt ores do not carry sufficient cobalt to receive payment for the cobalt.

Methods of Settlement Used

Although the treatment tariff for high silver ores is well established, the tariff for cobalt ores alone is largely a matter of grade, smelter requirements, and the ability of the smelter to dispose of its output. Of the four classes of ore described above, the shippers of No. 1 must pay the freight and a treatment charge of $20 a ton, and a refining charge for the silver of from ½c. to ¾c. an ounce. Depending upon the amount of silver, the smelters will pay for 95 to 98 per cent of the silver contained, at the New York official quotation on the date of settlement, which is generally thirty-five days after date of arrival. Cobalt is paid for at the rate of 2c. per unit per pound for ore running from 4 to 6 per cent, and 3c. per unit per pound for ore running over 6 per cent.

On the No. 2 and No. 3 classes, there is no treatment charge and no refining charge on the silver, and the smelter pays the freight where the rate is approximately $11 a ton. Cobalt is paid for at the same rate as in No. 1 class—that is, ore carrying 5 per cent metallic cobalt is paid for at the rate of 10c. per lb. of metal, or $10 per ton, f.o.b. shipping point: 6 per cent ore would be worth 18c. a pound, or $19.60 a ton; 8 per cent ore, 24c. per lb., or $38.40 a ton. If the ore contains silver, the smelters will pay for 90 to 95 per cent of the silver, depending upon the amount. Class No. 4, consisting of speiss containing iron, copper, and lead, has no market in this country, but there is a certain market for it in Germany. It will be seen from what has been set forth above that the price varies directly with the percentage of cobalt. In the average shipments the cobalt content does not exceed 8 per cent, but for an especially desirable ore running over 8 per cent, a premium is sometimes paid. Shippers who can guarantee a certain tonnage of a definite grade can usually obtain somewhat better terms than the shippers of single lots.

Varying Smelter Practice in Purchasing Ores

No payment is made for arsenic contained in the ores, although this is a valuable byproduct, and although no penalties are exacted for undesirable constituents, the smelters will refuse to accept cobalt ores which do not come up to their requirements. A number of smelters in the States will handle ores containing cobalt, but in which the cobalt is not the principal valuable mineral. They will not, however, make any payment for the cobalt contained, and in some cases will exact a penalty for arsenic. Only those smelters which produce cobalt will pay for cobalt in the ore.

The ore may be shipped in bulk or in bags, depending upon its value. All high silver ores are bagged, while residues and low silver cobalt ores are generally shipped in bulk. High silver ores are generally sampled at the shipper's expense before being shipped to the smelters, but low silver-cobalt ores may be sampled at the smelters without charge to the shipper. Settlement is usually made on a split between the smelter's and shipper's assay of the same sample, with the usual provision for umpire. Shipments are usually on the basis of car lots.

The price of cobalt metal is governed by general trade conditions in the ceramic and steel industries, and is fixed by a few producers, acting in agreement. Prior to 1907 the price of the metal was about $2.50 per lb., but with the extensive shipments from northern Ontario coming on a narrow market, the price dropped in the next few years to less than $1 per lb., with a corresponding decrease in the price paid for the ores. Since that time the uses for the metal have increased and its distribution has become better controlled, so that the price was gradually advanced to $4 per lb., but is now at the rate of approximately $3 per lb. If the output of the Tanganyika Copper Co. becomes an important factor in the market, there is the possibility of a decreased price in the future. A big spread exists between the price received by the shipper for cobalt in the ores and that at which the finished product is sold, but the process is complicated and expensive, the output is small, and a large investment in plant and equipment is required.

Canada Supplies Local Demands

Cobalt metal is not produced in the United States, but is produced in Ontario, England, France, Germany, and will also be turned out in the near future by the Tanganyika company, in Africa. Ontario has attained a dominating position in the production of cobalt metal, due to the fact that the mineral is produced as a by-product in the mining of rich silver ores. Most producers of cobalt metal and its salts prefer, however, to get an ore containing a high cobalt and low silver content, or one containing no silver, and there is a considerable market for ores of this sort, not only in Ontario but also in England and Germany.

Cobalt metal is cast in three forms—rondels, shot, and anodes. The production of anodes for cobalt plating is small, and only a small amount of the highest grade metal is produced as water-formed shot. Practically all of the metal is cast as rondels, which are slugs about one inch in diameter and three-quarters of an inch thick. Some domestic shipments of rondels are made in bags, but all rondels and shot for export are packed in small casks. The oxide, which is in the form of a powder, is shipped in larger barrels, with the exception of that for the Japanese trade, which demands special tin containers holding 5, 10, and 25 lb

Highest and Lowest Points in the World

The maximum difference in elevation of land in the United States is 14,777 ft., according to the U. S. Geological Survey. Mount Whitney, the highest point, is 14,501 ft. above sea level, and a point in Death Valley is 276 ft. below. These two points, both in California, are less than 90 miles apart. This difference is small, however, as compared with the figures for Asia. Mount Everest rises 29,002 ft. above sea level, whereas the shores of the Dead Sea are 1,290 ft. below sea level, a total difference in land heights of 30,292 ft. Mount Everest has never been climbed.

The greatest ocean depth yet found is 32,088 ft., at a point about 40 miles north of the island of Mindanao, in the Philippine Islands. The ocean bottom at this point is therefore more than 11½ miles below the summit of Mount Everest.

[1]The two principal producers at present are the Deloro Smelting & Refining Co. at Deloro and the Niagara Alkali Co. at Thorold.—Editor's Note.

A Tertiary Gold-Quartz Veindike at National, Nevada

By J. E. Spurr

THE WHOLE QUESTION as to the origin of ore deposits has been treated from a new viewpoint in my book on "The Ore Magmas." One of the conceptions which is there presented and argued is that many veins are filled, not by slow deposition from waters, but suddenly, by a highly concentrated or even viscous injection, which forces open a fissure by the pressure under which it is, and crystallizes after injection, much as a dike does. Such veins, formed in this way, I have called veindikes.[1] I first applied this explanation to the gold-quartz veins of Silver Peak, Nevada, in 1905; but in my book I apply this conception to a considerable proportion of all veins.

In agreement with and in accordance with this general conception is the description of a vein in the National mining district, Nevada, by Prof. Alexander N. Winchell, of the University of Wisconsin, in 1912,[2] which has recently come to my attention. The National district was noted, while it was active, for its rich gold ore. It lies in northern Nevada, near the Oregon line. The rocks are Tertiary lavas, belonging to two series: the older series consists of rhyolites and subordinate andesites: the younger series, formed after the erosion of the older series, consists of basaltic flows with some rhyolite and andesite. The sequence is: 1, rhyolite; 2, andesite; 3, rhyolite; 4, andesite; 5, basalt (and rhyolite).

The ore deposits are all in quartz veins. There are two types of veins: one contains copper, lead, and silver, the other gold (and silver). The former type of veins was formed after the older rhyolite (No. 1) which they cut, and probably before any of the later rocks. Their age is therefore between 1 and 2, above. The gold (silver) veins, however, were formed after the older andesite (2). The principal vein lies in a fault fissure which cuts the andesite; after the ore deposition, faulting continued, and involved the later andesite (4). The whole magmatic sequence would appear to be then: a, rhyolite; b, copper-lead-silver veins; c, andesite; d, gold (silver) veins; e, rhyolite; f, andesite; g, basalt (and rhyolite).

The older veins (b) contain mainly quartz, chalcopyrite, arsenopyrite, pyrite, bornite, stibnite, and galena. The values are in silver, copper, and lead. The younger veins (d) are quartz veins carrying native gold and silver in the proportion of 1 to 1 by weight. There is also some stibnite and native arsenic.

As to the origin of the younger vein, Professor Winchell writes:

"It is commonly believed that many ore deposits in veins have been formed by precipitation of metals, sulphides, or other compounds from flowing water or from flowing aqueous vapor. It seems reasonable to believe that such a mode of origin would produce a banding or crustification in the ore.

"At National crustification . . . is wholly lacking in the high-grade gold quartz, so far as I observed. It seems improbable, therefore, that precipitation occurred from a flowing fluid. I would suggest that the gold quartz was precipitated, not from a thin aqueous solution, but from a viscous and perhaps gelatinous mass which occupied the fissure in much the same way as an igneous magma fills an opening in country rock. The amount of motion during crystallization may have been no greater in the former instance than in the case of magma.

"If such a vein magma did at one time fill the National fissure it would certainly slowly cool, and perhaps at the same time slowly come under decreasing pressure on account of slight upward movement and surface erosion. Supersaturation would finally ensue, and centres of crystallization would be established.

"The existence of pockets or lenses of high-grade ore (electrum quartz) may be due, in part at least, to the process of crystallization. The electrum must be precipitated around those spots where centers of crystallization liberate the water. The noble metals may have been fairly uniformly distributed through the vein magma at the beginning of crystallization. As soon as crystallization commenced the metals would diffuse toward the centres of crystallization. Thus the electrum would form local masses in a vein quartz elsewhere nearly or wholly barren. After the precipitation of the electrum, the alkaline carbonates and sulphuretted hydrogen could escape from the crystallizing mass upward through the unsolidified portion (if any still existed) and outward into the adjoining rocks. These compounds would produce the secondary carbonates (calcite, ankerite, siderite) and sulphides (pyrite) which are found in the country rocks."

The rich gold-bearing portion of this vein does not come to the surface at any point. The upper 60 ft. from the surface carried some silver, but no high-grade ore: but from 60 ft. to 700 ft. were local segregations of rich gold (silver) ore whose worth as mined amounted to several million dollars.

The earlier ("base") vein of copper-lead-silver ore plainly represents, in accordance with principles I have set forth in "The Ore Magmas,"[3] an ore magma of moderately high temperature which reached very near the surface before it was deposited as a "telescoped" vein, with the normal copper-lead-silver zones[4] precipitated together; the later gold (silver) quartz vein was, however, formed at a lower temperature, though also very near the surface. It represents a type of vein which I have discussed in some detail in "The Ore Magmas."[5] Analogies may be pointed out at Tonopah, where, in Tertiary lavas, silver-gold quartz veins were followed at a later epoch by quartz veins carrying lead, zinc, and copper sulphides; with little gold or silver,[6] the sequence being reversed from that at National. A closer analogy is in the Camp Bird mine, also in Tertiary lavas, at Ouray, Colorado, where there was an earlier vein of (cupriferous) pyrite, blende, and galena (argentiferous), and a later vein of highly auriferous quartz; but at the Camp Bird both veins successively occupied the same fissure, making a compound vein.[7] I have described quartz veins of the general type of the rich National vein and the gold-bearing portion of the Camp Bird vein in several other districts, as at Aurora,[8] Nevada, where it is noteworthy that the proportion of gold to silver (by weight) varies from 1:40 to 1:2 or 3; but in the richest ore of one of the mines run 1:1, as at National.

[1] The Ore Magmas, Vol. I, p. 70.
[2] *Mining and Scientific Press*, Nov. 22, 1912.
[3] "The Ore Magmas," Vol. I, Chapter VI, p. 292.
[4] C-D-(E)-F-G zones, "The Ore Magmas," Vol. II, p. 703.
[5] G-H zone, "The Ore Magmas," Vol. II, pp. 699-706.
[6] "The Ore Magmas," Vol. I, p. 299.
[7] "The Ore Magmas," Vol. II, p. 683.
[8] "The Ore Magmas," Vol. II, p. 686 *et seq.*

DISCUSSION

"Engineering and Mining Journal-Press" is not responsible for statements or opinions published under "Discussion." In many cases the views expressed are diametrically opposed to editorial policy and belief.

Determining Native Copper in a Chalcocite-Copper Concentrate

THE EDITOR:

Sir—With regard to the inquiry on page 816 of the Nov. 10 issue of the *Journal-Press*: A few years ago, while employed by the Miami Copper Co., I did considerable work on the determination of oxidized copper minerals in the presence of chalcocite. Among other things, it was found that chalcocite was attacked by solutions of ammonia containing any ammonium salt, particularly the carbonate or the chloride. The action was very slow with the sulphate. It was also found that a sample containing chalcocite could not be dried without formation of an oxidized film on the chalcocite particles, which was easily soluble in ammonia containing ammonium salts as well as in dilute acids. I do not know of anything that will dissolve either metallic copper or chalcocite that will not attack the other. The metallic copper could doubtless be separated by amalgamation.[1] If the native copper is oxidized, it would be necessary to clean the sample with dilute sulphuric acid.

Tucson, Ariz. R. V. THURSTON.

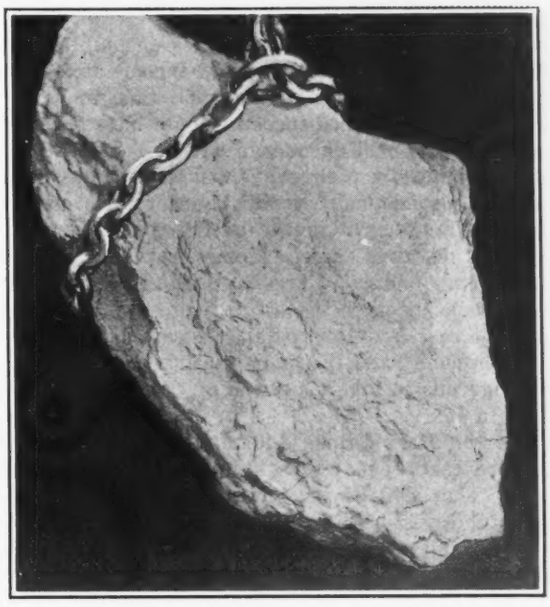
Aspen's Big Silver Nugget

THE EDITOR:

Sir—In line with the several letters and experiences concerning "Rich Ore" appearing in recent issues of the *Journal-Press*, I am enclosing you an old photograph of the "nugget" of native silver taken from the Smuggler Mine, at Aspen, in Colorado, in 1894. The print is somewhat faded, but it gives a clear idea of the shape and massive character of the specimen.

The "nugget," when brought to the surface, weighed 1,842 lb. avoirdupois, and was all pure silver. No piece of rock or other mineral adhered to its surface. David M. Hyman, of the Smuggler company, states that *several hundred pounds* of pure silver were broken off the main body when taking it from the stope and tramming to the shaft. The remaining portion was hoisted to the surface by a chain attached to the cable hook as shown in the print. The "nugget" was broken up and melted into bars.

This is the largest of a great number of similar "nuggets" found in the Smuggler, Molly Gibson, and other mines along the Silver Fault. In the Homestead mine in a stope, 90 ft. above the Cowenhoven tunnel level and 675 ft. below the surface, sheets of native silver filled the crevices in shattered quartzite. Miners would pick out the quartzite, work loose a corner of the silver sheet, and strip it off much as old paper is stripped from a wall. One such sheet measured 18 by 30 in. and had the thickness of a silver dollar. Several "slugs" were cut from this sheet the exact size of a silver dollar, and are still in existence in Aspen and Denver.



A pure silver nugget weighing 1,842 pounds

The recent wide publicity given the "nugget" of silver and *rock* found in north Ontario and claimed to be the richest ever found tempted me into mailing you the print with this brief description. B. P. SHARPE.

Pittsburgh, Pa.

Mine and Other Taxation

THE EDITOR:

Sir—Professor Haig, in his article this week, thinks Secretary Mellon wrong in disapproving of a capital tax because the charge-off of depreciation in mines may be affected. It is Professor Haig who is wrong. Mines should not be subjected to an income tax. They have no income. All they can pay is a capital tax. Mines do not breed mines. Therefore, the depreciation question should not come up in reference to an income tax. Secretary Mellon, instead of going too far, did not go far enough. Professor Haig should be the one to square him fully to correct principles, instead of writing as if the bureaucrats, demagogues, and tax-eaters are correct and principles must somehow be bent to square with them.

An income tax on corporations is wrong in principle anyhow. The stockholders must pay it. They are thereby obliged to pay very unequally and without any reference to their individual situations. Under the present law a poor widow with one share may pay under

[1] C. G. Maier: "Sulphur and Copper Oxide Determination," *E. & M. J.*, Feb. 2, 1918.

the highest bracket and get no dividend. Corporations are mere instruments of business. Tools, being productive, should not be taxed. Their use and increase should be encouraged. This was seen long ago by sheriff law. Picks and shovels cannot be levied upon under execution. Yet the income tax law violates this principle. The corporation, being intangible, is not seen to be as a mere pick or shovel. This is because our economists have had too little imagination to advance the science of economics materially beyond where Adam Smith left off.

Taxes should encourage saving. Consumption taxes would be best. Sales rather than income taxes would be better. It is harder to keep and save money than to make it. The earned income should have the higher tax, if any. It will encourage saving. The earner is not yet necessarily a saver. Until he is a saver he is little good, economically, to the country. He must pull more than his weight in the boat to put it ahead. A capital tax destroys credit. For every dollar of capital taken, twenty dollars of credit go by the board. Business is soon cramped, as at present, by too little development and by high costs. Current earnings have not yet become fixed in the capital structure, and it is less dangerous to take a portion of them, if there must be such a tax.

Professor Haig thinks $40 made by selling a bond should be taxed equally with its $40 coupon. Wrong again! That $40 advance was made by an investor. Successful investors are the salt of the earth. Civilization is built on them. They should be encouraged, not discouraged. The $40 coupon would have accrued. Therefore tax it. It handicaps fewer brains. It is by making business best that the world will be made to go around best—not by quack or socialistic nostrums to help the "masses." The latter are most hurt by the poor business which their self-assumed friends are always producing in order, as they think, to help them.

A poor mining engineer builds a home for $5,000. In a year he must move to another clime. Houses have gone up. He sells for $10,000. Government comes up with its so-called income blackjack and separates him from $2,500. But homes all over the world have gone up. At his new station he must also pay $10,000 for a home. He cannot now do it because his capital is now only $7,500. It was a capital tax—not an income tax. The capital had passed into his living structure, obviously, and he now feels its absence as he would the loss of a leg. It would be different if his future salary, merely, were reduced as by an income—a real income—tax. He has time and opportunity to accommodate himself to that.

I am the more ready to recommend only proper principles for your magazine because I do not think many of your engineer readers vote anyway. They move too fast. But they will start something in this country if they will begin correct economic thinking.

New York, N. Y. ERNEST G. STEVENS.

Receiving Stolen Goods

THE EDITOR:

Sir—With reference to the contribution by Mr. Adams in your issue of Nov. 10, which concludes with a general invitation to American capital to venture into Russia and Siberia, may I point out that American mining companies have not heretofore been accustomed to receive stolen goods knowingly, and I think it hardly likely that they will be attracted by the bland suggestion that they may thus reap where others have sown. Aside from the moral principle involved, they are, I believe, apt to foresee the obvious probability that after spending large sums for the development and equipment of mining properties they may find themselves in the same unfortunate predicament as the present private owners referred to by Mr. Adams, who are by force of circumstances willing to accept whatever the conscience of the Soviet concessionaires prompts them to give.

San Mateo, Calif. THOMAS L. JONES.

Chino in 1851

THE EDITOR:

Sir—In connection with Mr. Rickard's interesting history of the Chino enterprise, I call your attention to extracts from "Bartlett's Personal Narrative," Vol. I, published in 1854. John R. Bartlett was U. S. Boundary Commissioner in the years 1850-1853, fixing the boundary between this country and Mexico, from El Paso west.

The Santa Rita, now the Chino, mines are referred to by Mr. Bartlett only as "the Copper Mines," and he established headquarters there, in 1851, for these reasons:

"They are preferable to any other spot in this section for the establishment of a depot and location of headquarters; they are nearer the region which must be the field of labor, they are secure from predatory attacks. We find at the Copper Mines a fine, airy, salubrious spot, with some adobe houses abandoned at the breaking up of the settlement in 1838 on a threatened excursion of the Indians, good timber, limestone, a great plenty of wood for fuel, abundance of excellent grass for the animals, a supply of pure fresh water. The fortress that was erected for the protection of the former inhabitants is ample to accommodate all the troops and can be put in good condition for the purpose; in fact, Colonel Craig is now engaged in its reparation. The soil is good, as is indicated by the vestiges of the garden plots once cultivated and by the rank luxuriant growth of peach trees still in bearing condition; bears, deer, turkey, abound in the vicinity. The botanist will find a large and unexplored field; the geologist might make discoveries of permanent value to the country.

"Santa Rita del Cobre, as this place is called by the Mexicans, was for forty years an active mining town. Workings were commenced in 1804, and they proving very profitable, a population of about 600 gathered in the small open space here inclosed by lofty mountains. A considerable trade was carried on with border towns of Sonora. The nearest settlement was the Presidio of Janos, 150 miles off, though chief trains of supplies were sent from Chihuahua City, at a distance of 400 miles. The return trains took back copper ore; this was afterward sent to the City of Mexico, where, owing to its superior quality, it was used chiefly for coinage. It is said the owner had a contract with government to deliver the copper there at 65c. a pound, and that sufficient gold was found in it to pay all cost of transportation. I do not doubt the truth of this, as Mr. Courcier, who first worked the mine to advantage, amassed a large fortune from it, and Mr. McKnight, his successor, also found it very profitable. In 1838 a large train from Chihuahua was overcome by the Apaches in the canyon leading to the copper mines. They sent word to the inhabitants that they would allow no further supplies to reach them, and would, furthermore, destroy them when opportunity offered. Thus cut off from means of support and surrounded by warlike tribes, the people abandoned the place. It has remained unoccupied until now taken possession of by us this year.

"Several deep shafts were sunk by the Mexicans; vast heaps and extensive excavations show that an immense amount of labor has been performed here. One of the largest shafts has been filled up by earth caving in; others are obstructed by water. Some are still accessible and

are visited by many. If it should become an object to work the mines, they might be cleared without much labor. The rock is mostly feldspar and the red oxide of copper intermixed with native metal. Large quantities of ore deposited near the smelting house.

"On entering the excavations one sees the bright veins of the sulphuret of copper penetrating the rock in all directions, with here and there small masses of native copper; it is evident that all the hills in the vicinity are quite as rich as those which have been opened, as the same indications appear on the surface. But until there is some mode of transport other than by wagons near a thousand miles it will hardly pay to work them. It now costs 20c. a pound to transport goods from the coast at Indianola. Labor is cheap and plentiful in Mexico. At El Paso Mexican laborers can be had for 62½c. a day, they finding themselves; and can be procured at even less price.

"The height of the little valley where the mines are was found to be 6,250 ft. above the sea, and that of the mountain which rises abruptly from it, and to which the name Ben Moore has been given, is 8,000 ft.

"Gold is said to have been found here when the mines were worked; and many stories are told of large quantities that were buried when the place was abandoned. About four miles distant a deep shaft had been sunk, where it was said a skin containing more than $5,000 in gold had been buried. I saw many fine specimens of lead and one of silver ore, but I did not visit the localities. Mexicans who formerly resided here assured me that the existence of silver was known to many at the time, but being in the very heart of the Apache country, it could not be worked. The Indian chiefs told me they would show me where there was plenty of gold, but that they would not disclose the secret to others. I told them I did not come to their country for gold and declined the offer.

"But the great value of the Copper Mines region, which extends from the Gila eastward about 50 miles toward the Rio Grande, is in its fine forests. So rich a timbered country does not exist between the Mississippi Valley and the Pacific, except in the mountains of upper California.

"The buildings at the Copper Mines consist of a presidio, or fort, commanding the approach from the canyon below. It is of triangular form, each side presenting a front of about 200 ft., with circular towers at the corners. It is built of adobe with walls from 3 to 4 ft. thickness, and a single opening on the eastern side. This building is in so good a state of preservation that in a few weeks Colonel Craig made the whole tenantable for his command, and as storage for provisions. There are also fifty or more adobe buildings, some in good state, and some in ruins."

Mr. Bartlett speaks of the hunting; antelopes, bears more numerous than in any region they had been into, including grizzly and brown bear weighing up to 700 or 800 pounds; wild turkeys, quail, and trout from the streams. A paradise except for the lack of vegetables, and the soil was good but untilled and waste, due to the Apache pest. Several chapters of the book are devoted to incidents occurring at the Copper mines, notably those connected with the Apaches and their then great chief Mangus Colorado, with whom there existed a friendship, so that the commission was not disturbed by these Indians, who even went so far as to return to Mr. Bartlett animals and goods that had been stolen. The book is well illustrated, and there are many pictures of scenes at and near Santa Rita.

Duluth, Minn. DWIGHT E. WOODBRIDGE.

A Small Stockholder

THE EDITOR:

Sir—Your editorial in the issue of the *Journal-Press* for Nov. 17 on "Employee Representation on the Pennsylvania Railroad" was read with interest. Representation of employees is, no doubt, a change worth the effort and if this same representation were applied to the stockholders of corporations it would meet with the same good will and helpfulness on their part and would have a decided tendency to make the corporation "git up and git."

Imagine a corporation giving the employee a direct vote in the operation of the property and at the same time demanding the stockholder's proxy to carry on his interests without asking his ideas regarding the way affairs should be carried out. Instead of making statements, probably the best way to get ideas on the subject would be to make the subject a matter of questions and let others analyze them to bring out discussion as to the good and bad features of the personal vote.

1. If the United States Government can be properly controlled by the vote of the people, is there any reason why big corporations cannot be controlled by stockholders under the same means?

2. Why should our billions of wealth be controlled by a comparatively few men without restraint being placed upon them by the people who actually own the undertakings by the money they have invested in them?

3. Don't you think our money should be as well protected as our government affairs?

4. Don't you think that the executives of any big corporation should be put there at the head and controlled by all stockholders just as well as our local or national executives are controlled?

5. Don't you think the proxy too easy a means for officials to become unscrupulous?

6. Why are not our political officials allowed to float bond issues for us in just the same way that officials of our corporations are allowed to float them?

7. If proxies are the best means of voting in corporations why should they not be used in running a big government safely?

8. In speaking of capital and labor do you know to whom you refer?

9. What are the objections to corporations publishing a list of stockholders' names, their postal addresses and number of shares, as of a given date (for the benefit of stockholders only) other than the large number of names and the objections to publicity?

10. If the affairs of the company are of interest to one stockholder, are they not of more interest to all of them as a unit?

11. With the names of the stockholders being known to one another, don't you think there would be somewhat more of an effort made by those in charge of the company affairs to see that the stockholders received an income?

12. Do you think that finances should be reserved to posterity and your children's children in order to retain an organization and pay you a pittance on what is supposed to be a commercial proposition when revenue has actually been many times the dividends paid?

13. Should millions of dollars be spent on equipment in anticipation of greater business in years considerably in the future when such equipment is known to be inefficient at the time and probably will be antiquated before it can be put to proper use?

14. Don't you think a lot of these anticipated conditions are for the purpose of actually spending surplus and to evade government incomes at the expense of the stockholders generally? A SMALL STOCKHOLDER.

El Paso, Tex.

CONSULTATION

High-grade Manganese Ores and Specifications

"I do not know if you are producing a special article on marketing manganese, but I should be obliged if you could inform me (1) what exactly constitutes a manganese ore of chemical grade? I am aware that it is one going plus 82 per cent MnO_2. As you are aware some manganese contains a percentage of MnO. Does this affect the situation or is the total amount of Mn first estimated and is it then expressed in terms of MnO_2 for valuation purposes? What impurities render a high-grade manganese ore not a commercial chemical manganese ore? Why is there such a great price difference between a manganese ore going, say, 78 per cent MnO_2 and one going over 82 per cent MnO_2? Is there a large market in America, Europe, and England for a chemical manganese ore, in both lump and powdered form? How does the price of lump ore compare with powdered ore in America? What is the approximate monthly consumption of such ore of chemical grade in the three divisions mentioned? What countries produce the supply of such ore? Allowing for the import duty, how does the price ruling for chemical manganese ore in America compare with that ruling in England and Europe? From your market reports, I assume the present price of $75 to $85 in America is the internal price, duty paid, and that the expression 'gross ton' means a ton of 2,240 lb. Would it be possible for you to reply to these queries by letter?"

The Aug. 26, 1922, issue of *Engineering and Mining Journal-Press* contained an article by W. R. Crane entitled "The Marketing of Manganese." This paper answers most of the questions asked in this letter. W. C. Phalen in bulletin No. 173 of the United States Bureau of Mines also discusses various phases of the subject in a lucid and thorough manner.

The price of dioxide or chemical manganese ore depends primarily upon the amount of available peroxide present. Generally the highest grade of pyrolusite is used in chemical manufacture. Owing to its purity, it commands the highest prices for manganese ores. The schedule of prices is based upon the MnO_2 content, and although the highest grades are desirable—that is, those running above 85 per cent—those running as low as 65 per cent have been used, according to Crane. So far as we know, the ores are analyzed for their metallic manganese contents and the results converted into percentages of MnO_2 that may be present and active.

The impurities that affect the value of high-grade manganese ore and the fields in which it may be used are iron, lime, copper, arsenic, cobalt, and nickel. If the chemical ore is to be used in dry-cell manufacture, the ore should have a high available oxygen content present in the form of pyrolusite. Its physical appearance is also important, as the ease with which the ore can be decomposed and the oxygen freed is really more important than the manganese content. Dry-cell ore should have a minimum amount of iron and should be free from copper, nickel, cobalt, arsenic and other metals electro-negative to zinc. Copper is particularly harmful. According to Phalen, if these impurities are present in the electrolyte or as insoluble compounds they do no harm other than as inert or poor conducting materials. If soluble, their solutions diffuse to the zinc part of the cell, where they are deposited, causing useless corrosion of the zinc and deterioration of the cell. When in service this deleterious action is greatly hastened. Battery ore should be somewhat porous. Better life is obtained from a dry cell containing rather coarsely ground ore, as this can hold more electrolyte than finely ground ore. Careful grading of the manganese ore greatly influences the performance of a cell in electrical work.

In glass making, the impurities in the manganese ore which might affect the color of the glass have an important bearing on the value of the product. Before the war, ordinary specifications for manganese used in glass making were from 85 to 90 per cent manganese dioxide and less than 1 per cent metallic iron. The higher the manganese content and lower the iron, the better is the ore for glass making. The ore is sold in powdered, granulated, or lump form. Objections to the lump form are made because of the time required to melt it in the batch. Powdered ore is used principally when the batch is melted in pots; lump or granular ore is used when melting is done in tanks.

Estimates of the amount of manganese ore used in American industries other than the ferro-alloy industry range from 25,000 to 50,000 tons per year. We have no figures regarding the actual consumption in each of the chemical industries. The high-grade ores are produced in the United States, in Russia, Saxony, Japan, Nova Scotia, and other countries. Nearly all of them used in this country are imported.

Allowing for import duties and transportation charges, the prices of manganese ore in Europe and America are nearly always on a close parity.

Value of Cement Copper for Paints

"As a subscriber of the *Journal-Press* may I ask that you kindly furnish me with information as to the market for copper powder or copper 'cement' and whether your information is that this product is worth considerably more than electrolytic copper? If you will be good enough to furnish me with the above information and also with the names of some of the large paint companies who are consumers of this product at your earliest convenience, I will appreciate it."

Inquiry among numerous producers has failed to indicate that cement copper is worth more than electrolytic. In fact, the contrary is generally the case, as the cement copper has to be melted and purified before it can be marketed, and then as electrolytic copper. One of the largest American paint manufacturers informs us that his company does not use any cement copper for paint purposes—only a small amount of scale copper. We understand that attempts are being made in the West to manufacture a copper paint from cement copper for use in painting ships' bottoms. This is the same purpose to which scale copper is put.

Societies, Addresses and Reports

Arsenic Supply Promises to Be Adequate

Retailer Blamed for High Prices at Meeting in New York—More Would Be Used at Lower Figure

GOVERNMENT representatives, arsenic producers, calcium arsenate manufacturers, and representatives of boll-weevil victims met for their second annual powwow at the Commodore Hotel in New York on Dec. 7. The report of the Standing Committee on Arsenic, of which Dr. B. R. Coad is chairman, was read and elicited much appreciative comment.

In the "cotton year," Sept. 1, 1922, to Sept. 1, 1923, it is estimated that 31,000,000 lb. of calcium arsenate was sold in the United States, stocks at the end of the year being about 3,000,000 lb. Most of the farmers who poisoned their cotton used the dusting method, but some liquid preparations were used. The acreage treated was about 1,674,000 out of a total of 38,287,000 acres in cotton, or 4.4 per cent. The average quantity of calcium arsenate used per acre was 18½ lb.

Sales of white arsenic during the first half of 1923 amounted to about 6,000 tons. Production for the year is expected to be about 15,000 tons. If the implied production of 9,000 tons in the second half of the year is continued in the first half of 1924, a domestic supply of 18,000 tons will result. Imports are expected to be about 10,000 tons, which will make the total supply for the coming season 28,000 tons. As near as the demand can be predicted, with calcium arsenate selling for about 12½c. per lb., approximately 15,000 tons of white arsenic will be required for calcium arsenate manufacture, the minimum requirements for other arsenicals calling for about 10,000 tons more. So the supply and demand for the coming season should be taken care of easily.

No reliable data are available as to the reserves of arsenical ores in this country or in foreign countries. All available information was published by the U. S. Geological Survey in a bulletin recently issued entitled "Arsenic in 1922." It is desired that a survey of the arsenical ores in this country be made and that an appropriation be asked for the purpose.

It was brought out in the discussion that the use of calcium arsenate in boll-weevil control is to a large extent governed by the price. It is considered by the cotton growers that 10c. a pound is a fair price, and were the chemical selling at this level, much more of it would be used. When the price reaches 17 or 18c., only a small amount will be purchased, despite the alleged fact that the cost, even at the higher level, would be insignificant compared with the increased yield of cotton. It was also brought out that the poison was used to a large extent, during the last season, for the cotton-leaf worm as well as the boll weevil. Whether or not the cotton growers will be compelled to entertain this guest again during the coming season is unknown.

In the discussion considerable attention was also given to the price of calcium arsenate, an effort being made to find out who is responsible for present high prices, compared with those of a few years ago. Hamilton Brush made a creditable and plausible argument from the standpoint of the producers of white arsenic. Formerly a certain amount had to be produced, he said, and prices often covered only the bare cost of barreling and shipping it, thus obviating the necessity of finding a place to bury it where it would do no harm. American production then was as small as possible. Now, ore buyers are looking for high arsenic ores, expensive equipment has been installed to recover the arsenic, and the future market is decidedly uncertain.

Alexander Goulard, a representative of John Lucas & Co., manufacturers of calcium arsenate, showed that with arsenic selling at 12c. per lb., calcium arsenate could not be sold for less than 13c. a lb. and allow the slightest profit. If any one knew of a secret method for making calcium arsenate cheaper than by the standard method, he thought the process should be made public property.

Congressman Bill G. Lowrey, representing a cotton-growing district of Misssissippi in the House of Representatives at Washington, described the poverty of the cotton growers and indicated the impossibility of calcium arsenate being widely used at present exorbitant prices.

The only factor in the situation not represented apparently was the retail dealer in calcium arsenate. It was the sense of the meeting that it was here that the chief blame for high prices really lies.

Also in attendance at the meeting was Ira Williams, entomologist of the Georgia state government, who was asked about a recent contract made by the State of Georgia with an unknown corporation to supply a million pounds of arsenic a year, more or less, at 10c. per lb. He refused to discuss this contract, but it was intimated by others that the nearest the concern had come to fulfilling its contract was to secure some options on arsenic prospects in the State of Washington.

School of Mines Building "Gym"

A new gymnasium is now under construction at the New Mexico School of Mines, Socorro, N. M. The building will be approximately 50x100 ft. It will have a regulation basket-ball court and dressing rooms.

Curry Resigns as Secretary of A. M. C.'s Arizona Chapter

The annual meeting of the Arizona Chapter of the American Mining Congress was held in Phoenix, Ariz., at the Adams Hotel on Dec. 3. Nearly all of the large mining companies of the state were represented. G. M. Colvocoresses, governor of the chapter, announced that headquarters would in the future be in Phoenix, instead of Prescott. All officers were re-elected for another year, with the exception of J. Curry, of Bisbee, who submitted his resignation as secretary before the meeting. William B. Gohring, of Tucson, was elected to fill the vacancy created by the resignation of Mr. Curry. Other officers of the chapter are: G. M. Colvocoresses, Southwest Metals Co., Humboldt, governor; W. S. Boyd, Ray Consolidated, Ray, first vice-governor; T. H. O'Brien, Inspiration Consolidated Copper Co., second vice-governor and John C. Greenway, Calumet & Arizona, Warren, third vice-governor.

B. C. Mining Association Elects Officers

The general annual meeting of the Mining Association of Interior British Columbia was held at Nelson on Dec. 8, when the following officers were elected for the ensuing year: R. Randolph Bruce, president; J. P. McFadden, vice-president; W. H. Burgess, secretary-treasurer; H. Geigerich, auditor; and James Anderson, E. G. Montgomery, W. T. McDowell, Douglas Lay, S. S. Fowler, T. W. Bingay, and S. G. Blaylock, executive committee. The secretary said that the Hon. John Oliver, Premier of British Columbia, assured the deputation that was sent by the association to consult with the government on mining taxation that the bonds of the Coast Range Steel Co. would not be guaranteed by the provincial government.

Short Mining Course Open for Prospectors

The winter mining session of the College of Mines, University of Washington, will be held for the twenty-eighth year at Seattle from Jan. 4 to March 20, 1924. The courses are open without examination to anyone interested in mining. Expenses consist of the cost of materials actually used and a university fee of $20.

The studies are arranged in four groups: quartz mining, placer mining, coal mining, and ceramics. In addition to the fundamental subjects such as geology, mineralogy, chemistry, and drawing, specialized training is given in ore mining methods, mine surveying, mining law, milling (including flotation), assaying; hydraulics, gold dredging; coal analysis, coal washing, clay testing, manufacture of clay products, and cement.

The session has proved interesting in past years to many prospectors and mining men from Alaska, British Columbia, and the northwestern states.

Recent Technical Publications

Reviews, Abstracts, and References

The Welding Encyclopedia. Compiled and edited by L. B. Mackenzie and H. S. Card. Third edition. Published by the Welding Engineer Publishing Co., Chicago. Price, $5.

Three editions of this book have now appeared in successive years, attesting to the demand for the book and the determination of the editors to keep it up to date. This latest volume has a new chapter on training operators in oxy-acetylene and electric arc welding, and much additional matter on the welding of tanks and pipes.

Sulphur Dioxide Leaching—Sulphurous acid leaching of oxidized copper ores has been given a large amount of attention by the Southwest Experiment Station of the U. S. Bureau of Mines, and exhaustive experiments have been made, not only at the Tucson station but at plants of the Arizona Copper Co. at Clifton, and of the Miami Copper Co. at Miami. The work is not yet completed, but so much interest has been aroused that the Bureau has issued a report on what has been done to date. This is entitled "Leaching Non-sulphide Copper Ores With Sulphur Dioxide," and is published as Technical Paper 312 of the U. S. Bureau of Mines, Washington, D. C., 91 pages, obtainable on request from the Bureau, or for 20c. from the Superintendent of Documents, Washington, D. C., when the Bureau's supply is exhausted. It will be found of much interest to any metallurgist who has followed the hydrometallurgy of copper. No conclusions are expressed as to the likelihood of the commercial utilization of the process, these being reserved for a later bulletin. We understand, however, that no company is now considering using this method of treating low-grade oxidized ore, preferring sulphuric acid as the solvent.

Flotation of Cement Copper is discussed in an appendix to the bulletin just mentioned, a report of Walter G. Scott on the subject being abstracted. The work at Tucson and at the Chino Copper Co.'s mill at Hurley is mentioned. It is stated that the future of copper leaching followed by flotation recovery depends largely on the manufacture of sponge iron. Our personal information leads us to believe that the manufacture of sponge iron has been pretty well solved at the Chino (we are going to have an article on the subject just as soon as the information is released), but that a satisfactory flotation recovery of the cement copper by flotation, and the securing of a properly high-grade product acceptable to smelters, has been more or less disappointing.

Aluminum Paint—An informative little booklet on the properties and use of aluminum paint has been issued by the Aluminum Company of America, Pittsburgh.

Commerce Yearbook—An authoritative review of business for 1922 and the early months of 1923 is embodied in the first annual issue of the "Commerce Yearbook," 692 pages, recently issued by the U. S. Department of Commerce, and obtainable from the Superintendent of Documents, Washington, D. C. for 60c. Much general commercial information is given in this volume, but our readers will no doubt be particularly interested in the report of the non-ferrous metal industries, which occupies 11 pages, in the chapter on the iron and steel industry, 15 pages, and that on the petroleum industry, of 17 pages. The volume should make a valuable reference book. The next issue is to be published early in the spring of 1924.

Detonating Compound—"The Preparation and Properties of Normal Lead Trinitro-resorcinate" is discussed in a 6-page paper issued by the U. S. Bureau of Mines, Washington, D. C., for free distribution, as *Reports of Investigations* No. 2,533. This compound has been suggested as a substitute for fulminate of mercury. It was found by the Bureau to be about 75 per cent as strong as mercury fulminate, insensitive to friction, and less sensitive to impact than fulminate. It cannot be used as an initiator of military high explosives, but will detonate some industrial dynamites. It may be mixed with potassium chlorate, thus making a mixture of the same strength as straight mercury fulminate.

For Montana Prospectors—University of Montana Bulletin No. 5, published by the State School of Mines, Butte, Mont., is entitled "The Location, Representation, and Patenting of Mineral Lands in Montana." The prospecting and leasing of coal, oil, oil shale, gas, phosphate, and sodium deposits is covered. The bulletin deals mainly with interpretations of the state and federal mining laws.

Slate Quarrying—A process of drilling and broaching as a substitute for channeling and blasting is now being tried out in certain Pennsylvania slate quarries in an effort to reduce the waste due to shattering. The work is described by Oliver Bowles in U. S. Bureau of Mines *Reports of Investigations* No. 2,532, 6 pages, obtainable on request from the Bureau at Washington, D. C.

Phosphate Fertilizer Manufacture—A four-page article in *The Anode* for October (Anaconda Copper Mining Co., Butte, Mont.; free) describes the operation of Anaconda's fifty-ton experimental plant for the manufacture of mono-calcium phosphate from rock mined at Conda, Idaho. A new plant is under construction, to have a daily output of 100 to 120 tons of treble superphosphate.

Mineral Resources—C. M. Campbell's article in the *Bulletin* of the Canadian Institute of Mining and Metallurgy for December (26 pages; 603 Drummond Bldg., Montreal; price 50c.), entitled "Publicity and the Mining Industry," should be read by those who think mineral resources on this continent are unlimited and that nothing serious can ever happen to us so long as we have them.

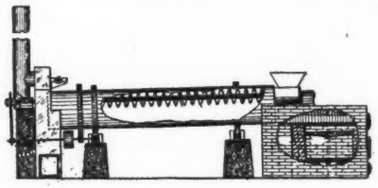
Sulphur—The same bulletin mentioned in the preceding paragraph contains a 12-page general article on sulphur, discussing its distribution, production, and uses.

Arsenic—"Arsenic, Calcium Arsenate, and the Boll Weevil" is the title of a 42-page booklet recently issued by the Barr-Erhardt Press, 205 West 19th St., New York City, price 50c. It is made up of articles and addresses by Howard W. Armbruster made in the last year or two, and discusses practically all phases of the situation, including technology of production.

Canadian Geological Survey—Summary Report, 1922, Part A, 145 pages, with charts and maps, has recently been issued by the Canadian Geological Survey, Ottawa, Ont., for free distribution. The report covers explorations in several districts in British Columbia.

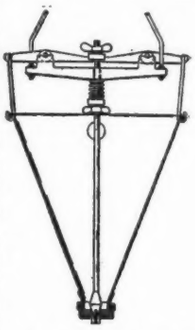
Patents

Drier—No. 1,469,294. Oct. 2, 1923. A. C. Daman, Denver. A revolving



drum drier of the type indicated in the accompanying illustration.

Dewatering Cone — No. 1,468,374. Sept. 18, 1923. H. K. Burch, Los Angeles. A device for separating water from solids in tailing, comprising a cone having an overflow near its upper end and a sand outlet at its lower end. The cone is suspended so that as its weight increases owing to accumulation of sand, a valve at the lower end will be opened, thus allowing the sand to come out. The valve is closed by a spring, as shown in the accompanying illustration.



Copper-Zinc Separation—No. 1,468,988. Sept. 25, 1923. Charles Berthelot, Paris, France. A solution containing copper and zinc is treated with hydrogen sulphide, the precipitated copper sulphide separated, and further quantities of the metals dissolved in the remaining solution.

MEN YOU SHOULD KNOW ABOUT

J. A. Carpenter is now on the faculty of the University of Southern California.

L. T. Pockman, of Los Angeles, is in New York. He expects to return to California by Christmas.

Fred H. Siebert has returned to Reno from Randsburg, Calif., where he is directing mining operations.

Henry Wyman and **Walter Harvey Weed** are in the State of Zacatecas, Mexico, on an examination trip.

Walter S. Palmer is at present acting as head of the Mackay School of Mines. He also directs the courses in metallurgy.

J. W. Sherwin, general manager for the West End and Halifax companies, at Tonopah, is in Tonopah from his Oakland headquarters.

Clyde A. Heller, president of the Tonopah Belmont Development Co., has been in Tonopah on a short trip of inspection of the local property.

Morton Webber and three assistants were in Mexico City recently, and left to conduct an extensive mine examination in the State of San Luis Potosi.

Benjamin D. Goodier, mining engineer of Colorado and now operating fluorspar mines on the Gila River near Silver City, has been examining manganese deposits near Rincon, N. M.

Pentecost Mitchell, vice-president, and **John H. McLean**, general manager, of the Oliver Iron Mining Co., made a recent inspection tour of their company's properties on the Mesabi iron range.

F. A. Woodward, general manager of the Iron Cap Copper Co., Copper Hill, Ariz., has just returned from a visit to Boston, where he conferred with the directors of his company.

Prof. Frederick Leslie Ransome, of the mining department of the University of Arizona, has spent the last week with a class of his students visiting the mines of the Superior, Globe, and Miami districts.

D. C. Jackling has just finished his annual visit to the Chino Copper Company mines and took opportunity at the same time to kill a bear and a deer in the big forests adjacent to the mines on the north and east and west.

Garret Mott, chairman of the board of directors of the Superior & Boston Mining Co.; **Dr. E. C. Holden**, mining engineer, and **Robert Garret**, of Baltimore, have been in Arizona for some time, visiting the company's property at Copper Hill and other holdings in which they are interested.

Axel O. Ihlseng, engineer of New York City, has been examining the milling operations of the Chino Copper Co. at Hurley, and at the same time has looked over the district in general. Ten years ago he operated zinc and lead mines in the Cooks Peak district.

E. T. McCarthy, of London, England, recently completed a professional trip through the South Lorrain and Porcupine districts of Canada. He sailed from New York for London on Dec. 15. Mr. McCarthy expressed himself as being impressed with the possibilities of the Keeley mine.

Horace F. Lunt has been appointed by Governor Sweet of Colorado to act

Horace F. Lunt

as trustee of the Colorado School of Mines to fill out the term of R. D. Brooks, resigned.

Dr. L. I. Shaw, of the U. S. Bureau of Mines, has been selected to direct the research work on silver of the Senate Commission of Gold and Silver Inquiry.

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Dr. L. I. Shaw

Dr. Shaw has been for many years assistant chief chemist in the Division of Mineral Technology. He has been transferred to the Division of Metallurgy and will devote his entire time to silver research. Dr. Shaw's preliminary work will be done in co-operation with the Bureau of Standards.

Alford Roos, consulting engineer, of Bayard, N. M., has returned from the Embudo River country in Taos County, where he has just finished a year of intermittent geological work pertaining to the lepidolite-bearing pegmatite bodies in the pre-Cambrian schists of those regions.

Gordon Campbell, president of the Calumet & Arizona Mining Co.; Thomas **Collins**, **George A. Newett**, **Captain Tom Hoatson**, and **Dr. Briggs**, son of Charles Briggs, deceased, the first president of the company, all of whom are company officials and directors, have been making their annual inspection of the company's properties in the Southwest.

L. R. Davidson was elected president of the Davidson Ore Mining Co. at the last meeting of the board of directors held in Buffalo. Mr. Davidson was formerly treasurer of the company and was elected to fill the vacancy occasioned by the death of F. N. Beegle. **T. F. Hildreth** was elected to assume the duties of the treasurer besides his present duties as secretary.

Major Copeland and a large party of associate doctors from Fort Bayard, N. M., have been spending a week at their Andy Strum mine, in the Black Range. Combining business and pleasure, they timed their visit to coincide with the hunting season. In this respect, their mine is so happily situated that one can shoot deer and wild turkey from the doorways of the camp houses.

Charles W. Merrill, of Berkeley, Calif., at a recent meeting of the board of directors of the A.I.M.E., was awarded the Douglas medal, for an important improvement in the practice of cyanidation.

Jack L. Merrill, senior at the University of California, has been named as Rhodes scholar from California to Oxford University, England. He is the son of Charles W. Merrill.

Al Owens, of Santa Rita, a well-known mining operator and famous in New Mexico and Joplin for the number of fortunes made and lost in mining ventures, has started a new mine operation on lead and silver near the summit of Cooks Peak, and is active in moving machinery there. He is at the same time running, in a small way, his Royal John mine and the mill, in the Black Range. This is a complex lead-zinc deposit.

F. R. Wadleigh, former federal fuel distributor, will retain his connection with the Bureau of Mines under a specially arranged consulting relationship. Prior to his appointment as federal fuel distributor and since the termination of that office Mr. Wadleigh has served the Bureau of Mines and the Department of Commerce in a joint capacity. Under the new arrangement, he will attend at least one conference a month with Bureau of Mines officials in Washington.

H. G. Dalton, **Elton Hoyt, 2d**, and **C. H. Munger**, members of the firm of Pickands, Mather & Co.; **C. A. Buck**, vice-president of the Bethlehem Steel Co.; **C. S. Robinson**, vice-president of the Youngstown Sheet & Tube Co., and **Dr. C. K. Leith**, professor of the geological department of the University of Wisconsin, recently made a visit to the various properties of the respective companies in the Lake Superior district. They were accompanied by **W. P. Chinn**, general manager, and **W. A. Rose**, assistant general manager, of Pickands, Mather & Co.

THE MINING NEWS

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Summary of the Week

GEORGE W. LAMBOURNE, in behalf of the Park City Mining & Smelting Co. and allied interests, has negotiated the purchase of the controlling interest in the famous Ontario silver mine. In conjunction with the Park-Utah, Daly, Daly-Judge, and West Ontario properties this puts the greater part of the Ontario fissure system under one control.

An active winter is assured on both Mesabi and Vermilion iron ranges in Minnesota.

The "million dollar" crusher plant of the United Verde Mining Co. at Jerome, Ariz., is ready for operation.

Exploration in both the old and new properties of the district is the greatest need of Oatman, Ariz.

Rumors that the Cananea Copper Co. will suspend operations in the near future are denied by officials.

The Nipissing Mining Co. is more than earning its current dividends of $1,080,000 per annum.

The Anaconda Copper Mining Co. is considering the erection of a custom plant for the treatment of zinc-lead ore at Park City, Utah. The zinc concentrate would go to the electrolytic plant at Great Falls, Mont.

D. C. Jackling and other engineers bag bear, lion, deer, and turkey in the mountains near Silver City, N. M.

Research into new uses for silver will be conducted at the Bureau of Mines Experiment Station, at Reno, Nev.

The West End Mining Co. has opened new gold ore-shoots in the Mabel mine, near Mina, Nev.

Several old arsenic mines in the Keystone district of South Dakota have been reopened.

Arsenic Mines in South Dakota Are Being Reopened

Keystone Arsenic Co. Plans to Build Plant—Feldspar and Mica Are Shipped

Mining activity has been resumed in the Keystone district in South Dakota, and at the present time a large force of men is employed at various mines. More recently work has been started on the arsenic properties, including the Bullion, Ida Florence, Bismarck, and adjacent mines. The work is being done under the management of H. R. Eyrick, formerly with the J. G. White Engineering Co., of New York City. Associated with Mr. Eyrick are H. C. Bacorn; general manager of the Jardine Gold & Mining Co., of Montana, and F. W. Bacorn. Funds for the work have been supplied by individuals, and the Keystone Arsenic Co. is being organized as a closed corporation.

At the Ida Florence a new headframe has been erected, a boiler and hoist have been installed, and the unwatering of the 300-ft. shaft has started. The old workings of the Bullion are being placed in shape for active work. The Blue Bird ten-stamp mill has been purchased, and this will be used in the present operations. The plant is equipped with Wifley tables and plates. The new owners of the arsenic properties have also secured a site in the town of Keystone and plan to erect an arsenic treatment plant similar to the one at Jardine, Mont.

The Keystone Feldspar & Chemical Co. has shipped its first car of feldspar to the Commercial Feldspar Co. of Chicago, and this is being tested. Should the tests prove satisfactory, the company will construct a treatment plant at Keystone and the large deposits at the Etta, Peerless, Hugo, and Ingersoll mines will be marketed.

Regular shipments of mica are being made from the Peerless mine, which is being worked under contract. The Maywood Chemical Co. has been active for some months and shipments of lithia ores are being made. The Ingersoll mine is also producing shipments of lithia ore and in addition columbite and beryl have been shipped from the district within the last few months.

Burnt Fork Company, in South Dakota, Builds Mill

The Burnt Fork Mining & Milling Co., whose property is five miles from Hill City, S. D., has erected a small plant. A test run was made some weeks ago, and approximately forty tons of ore, taken from the dumps and shallow workings, gave bullion returns of $400 on the plates. In addition to the gold the ore also shows values in arsenic. Though operations have been on a small scale, the mine development is being continued with depth and the new concern gives promise of becoming a regular producer.

Silver City, Idaho, Latest Old Camp To Revive

Search for Lateral Extension of Veins —150-Ton Concentrator Will Be Run—Never Sweat Reopened

The old camp of Silver City, in Owyhee County, in southwestern Idaho, is experiencing a revival after lying dormant for many years. The camp was discovered in 1866, and for many years was a heavy producer, records showing silver and gold totaling $20,000,000. Recently efforts are being made to trace the veins on their extension into virgin territory.

The prevailing rock is granite covered by ryolite flows through which the veins have cut to the surface. Intrusive dikes cut the formation. The gold is free in the oxidized ore.

At the Never Sweat property quarters for a crew of forty men are being finished and exploration will be pushed this winter. The Great Western Mines Co. is doing exploration work on the extension of the Golden Chariot vein. The Red Jacket company has a 150-ton plant about ready to run on a property south of the Cumberland. John B. Platts has a bond on the Mountain Chief, owned by James Murray since 1888. E. P. Kellogg has taken an option on the Village Blacksmith and is mining ore for shipment to the smelter.

The camp is 25 miles from the Oregon Short Line R.R. at Murray.

Anaconda Has Plan for Getting Park City Zinc Concentrate

May Construct Modern Plant to Treat on Custom Basis—Zinc Products Would Go to Great Falls

The erection by the International Smelting Co. of a modern plant for the treatment of lead-zinc ores at or near Park City, Utah, is being considered. The Silver King Coalition, Park City Mining & Smelting, and Park-Utah mines are to be examined at once by engineers representing these companies and the International Smelting Co., subsidiary of the Anaconda Copper Mining Co., as a preliminary step toward working out a plan of treatment for certain lead-zinc ores of the district. The primary purpose is to determine the tonnage of ore available. If an agreement can be reached on ore-treatment rates, the smelting company will build a modern plant to mill the ores from the above-named mines to recover the zinc and to produce a high-grade smelting product which will be practically free of zinc. If the plan is carried out the zinc concentrates would go to the Anaconda company's Great Falls electrolytic zinc plant.

White Caps Mill Restarted on $18 Ore

The White Caps mill, at Manhattan, Nev., is again in operation. The roaster relining is completed, and the mill is treating at the rate of 2,000 tons of ore per month. Mill heads are said to average $18 per ton in gold. In addition to the ore milled in its own plant, the White Caps is shipping 150 tons of arsenical ore per month to the plant of the Arsenic Products & Refining Co., at Martinez, Calif. Here the arsenic is extracted and the ore reshipped to the Selby smelter, where the gold is recovered. The ore carries about 25 per cent arsenic and $25 per ton in gold.

Bentonite Shipped from South Dakota

Two carloads of bentonite have been shipped from the Stetta property, at Bell Fourche, South Dakota, to New Jersey, where it is being tested. The deposits are extensive and the material is of excellent grade. In addition to the above property, the Bell Fourche Bentonite Products Co. has been incorporated. This concern owns more than 3,000 acres of bentonite land near Bell Fourche and is making arrangements for building a grinding plant.

Will Build Fluorspar Concentrator in New Mexico

Mike Kennedy, millwright and engineer, has been engaged by Frank Merrill, manager of the Nakaye Fluorspar Corporation, to build a 200-ton fluorspar concentrator near Derry, N. M. Water will be pumped from the Rio Grande River to the mill. The mine is two miles further up in the high hills and the ore will be hauled or trammed to the mill from the mine. This mine has been working more or less steadily for four years. It is unique among New Mexican fluorspar deposits, in that it is a flat-lying blanket deposit in fossilized limestone; it covers the top of a low range of barren mountains.

Lambourne Interests Buy Ontario in Park City

By Wire from Salt Lake City

A CONTROLLING INTEREST in the Ontario silver mine, at Park City, Utah, has been acquired by George W. Lambourne and associates, who have purchased the Bamberger holdings. The Ontario company owns a four-sevenths interest in the Weber coal mine and in the Ontario drain tunnel; likewise a controlling interest in the Nail Driver mine, and substantial interest in Keystone mine of Park City. The Ontario mine has been one of the world's greatest silver producers; it was purchased in the 60's by George Hearst for $30,000 and has a production record to date of nearly $50,000,000, from which over $13,000,000 has been paid in dividends. This transaction completes the formation under one control of a compact group on Ontario fissure system from the Park-Utah on the east, through the Ontario, Daly, old Daly West, Daly Judge, and West Ontario mines. The Park City Mining & Smelting interests, headed by Mr. Lambourne, dominate this part of the district.

Rouyn Township, in Quebec, Scene of Active Prospecting

New gold discoveries are reported from the Rouyn district of northwestern Quebec, and prospecting is active. The latest find is in Fournier Township, about 40 miles from Rouyn Lake, where free gold is reported over a considerable area. A short time prior to this new discoveries were also made in the sediments in the southern part of Rouyn Township and the Coniagas company of Cobalt has taken an option on a large acreage there. Prospectors who last fall were rather discouraged are now returning to the district, and the large mining companies are again sending their scouts into the field. In Rouyn Township the Noranda company has a considerable number of men at work, and is diamond drilling and sinking; the Nipissing is sinking on the Powell group; and the Coniagas will surface prospect the property it has under option. Further east Alderson and MacKay are actively exploring the Lake Fortune property, and development is to be started on the latest discovery in Fournier Township. The Quebec field embraces an area of approximately 1,000 square miles, of which the surface has only been scratched in a comparatively few places.

Mining Men Kill Big Game in New Mexico

D. C. Jackling and Others Get Lion, Bear and Turkey—Last Retreat of Wild Life in Country

The New Mexico big game hunting season, three weeks beginning Nov. 20, witnessed the gathering of many mining engineers and operators. The biggest and best game and fish country within the nation's borders is the region adjacent to Silver City, taking in the expansive Black Ranges, and the Mogollon and Datil Mountains. D. C. Jackling and his party met with great success at the headwaters of the Sapello. To the rifle of Mr. Jackling fell a large grizzly bear, a large buck, and all the wild turkey the law would allow. John M. Sully, manager of the Chino Copper Co., secured an unusually large blacktail and a lion. Frank Thurber, engineer for the Chino, also got a deer. Robert McCart and J. W. Crowdus, of El Paso, got all the law would allow. Alford Roos, engineer of Bayard, N. M., got a blacktail and a black bear. L. M. Kniffin, manager of the Hanover Bessemer Iron Co., got a lion and a deer. In fact, no hunter came out without at least a deer, and most got the limit in wild turkey. This is the last stronghold of the wild turkey in the United States. This bird, almost extinct, is yet plentiful in the remote fastness of the Black Range.

Among the many wonderfully equipped pack-trains of the hunters were noted parties of wealthy Indians from Oklahoma. These Indians arrived late and bought lavishly in camp equipment from the local supply houses. They were the guests of Fred Harvey, of Harvey House fame.

San Rafael Made Money During Third Quarter

The San Rafael y Anexas Mining Co., operating at Pachuca, Mexico, during the last three months treated 37,321 tons of ore, with an average content of 365 gm. of silver to the ton. The output was 11,809 kg. of silver, being an increase over the former productions during the year for the same period of time. Development work totaling 759 m. was done during these last three months and considerable ore was blocked out. The San Rafael Company has been reported as in some financial difficulty, but the directors report an improvement in these conditions.

Alaska Juneau Lost in November

The Alaska Juneau mined and trammed to its mill 188,300 tons of ore in November, 1923. The recovery was $108,500, or 57.61c. per ton. Operating expenses totaled $95,750, or 50.84c. per ton The operating profit was $12,750, or 6.77c. per ton. Other expenditures and accrued charges, including $12,500 on capital account and $14,750 interest, totaled $27,250, leaving a deficit of $14,500 for the month.

New Mill Near Austin, Nev., Nearly Ready to Run

Rapid progress is being made in the installation of a new milling plant by the Warner Mining & Milling Co., owning a property situated about thirty-five miles south of Austin, Nev. Practically all of the outside work has been completed. By Jan. 1 the plant will be under cover, at which time installation of machinery will be rushed. The plant uses table concentration and flotation. In the meantime the 1,500-ft. tramway connecting the mine with the new mill should be finished, thereby solving the transportation problem.

The lower adit driven into the formation 900 ft. has been connected with the upper workings by a raise 125 ft. high. Chutes have been put in, so that the ore can be dropped from the upper workings to the lower tunnel and hauled thence to the portal, where it will be loaded into the new tramway.

Sufficient water for all milling purposes has been developed by the company near its new mill site.

Although the ore is siliceous and presents a fairly difficult metallurgical problem, A. O. Jacobson, the manager, is confident that a high recovery can be made. The mineral developed is high-grade silver ore carrying a small percentage of both lead and copper.

Yuba Consolidated Profits Less; Ground Leaner

Dredging operations of the Yuba Consolidated Gold Fields in California for the fiscal year ended Feb. 28, 1923, were as follows: Total returns, $2,043,304.92 (8.5c. per cu.yd.); total expenses, $1,093,109.77 (4.55c. per cu.yd.); operating profit, $950,195.15. The operating profit was $1,056,863 less than that of the previous year. This was due to working in low-grade ground. A higher profit is expected during the remainder of 1923.

The company has acquired additional ground along the Yuba River and recently constructed a new road to the Browns Valley road from its new area. Five dredges are now in operation.

Exploration Big Need of Oatman District, in Arizona

Reserves of Producing Properties Near Exhaustion—Two New Mills Under Construction—Good Roads and Cheap Power Help—Opportunity for Prospector

By George J. Young
Associate Editor

THE continued prosperity of the Oatman gold district, in Arizona, depends upon the opening of new orebodies in both the old and new mines. That exploration will disclose large and profitable orebodies seems likely.

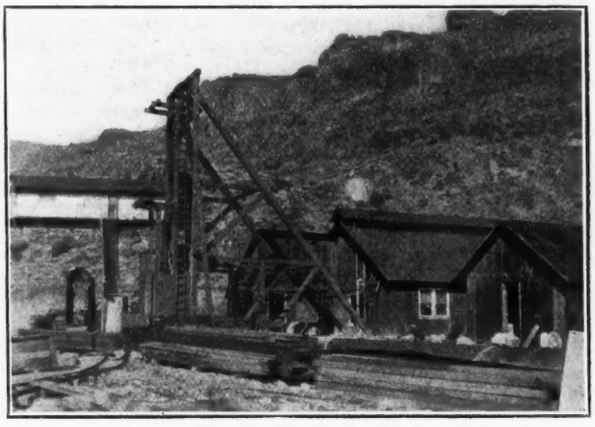
Three large properties are operating —the United Eastern, producing 300 tons per day; the Tom Reed, 150 tons; and the Gold Road, 120 tons, a total of 570 tons per day. The aggregate milling capacity of the three mills now in operation is 900 tons per day. However, the estimated remaining life of the three properties is relatively small, a few months for the Tom Reed, probably less than a year for the United Eastern, and a few months for the Gold Road. The United Eastern is deriving its ore supply from the Big Jim mine, and the Tom Reed from the Aztec. The Gold Road is an old property, and hope of further discoveries appears to have been abandoned. Likewise with the United Eastern and Tom Reed properties, exploration has not resulted in significant discoveries.

Gold mines sometimes die hard, and the apparent short life of these three properties may exceed the present forecasts. The aggregate footage of development and prospect workings on the United Eastern exceeds five miles, that of the Tom Reed is more than seven miles, and that of the Gold Road in excess of five miles. From these figures it would appear that the three ore zones in question had been pretty well explored. To April, 1922, the Tom Reed property had produced bullion to the value of $9,488,622; the United Eastern up to the end of 1922 milled 592,238 tons and recovered over $11,000,000 in bullion. The production of the Gold Road is not available.

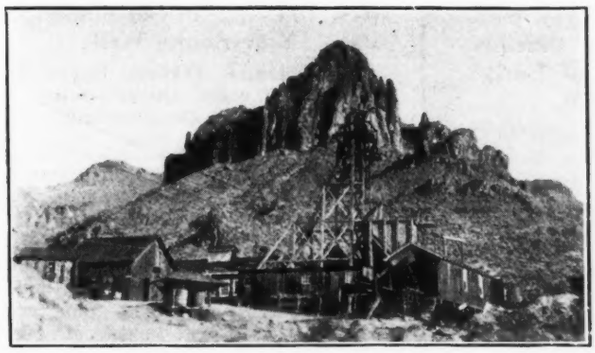
Two small mills are under construction, one by the Oatman United Gold Mining Co. and the other by the Telluride M. M. & Development Co. The former is to be a 75-ton mill designed by Sill & Sill, of Los Angeles. The milling system is all-sliming, with solution of the gold and silver by cyanide and precipitation upon copper plates by electrolysis. The solution will be recovered by an Oliver filter. The latter mill is to be of 45-ton capacity and will use the cyanide process as applied in the district. A sorting belt for the removal of waste and washing sprays for cleaning the ore preliminary to sorting are included in the design. In addition, the Gold Dust Mining Co. has rehabilitated a 10-stamp mill on its property and has installed a patented centrifugal amalgamator for the recovery of the gold. The mill was being given a tryout at the time of my visit. The mine surface plant, which had been considerably damaged by a recent fire, was almost in operating condition. All three of the properties mentioned are said to have orebodies and sufficient development to begin stoping as soon as their milling arrangements have been completed. Thus continuity of production for some time is assured, although on a smaller scale than at present maintained by the three larger properties.

In addition to the foregoing, the following properties are at work, chiefly exploring the possibilities of their ground: Amalgamated, Lucky Boy, North Star, American, Lexington, United Republic, and a lease upon the Alcyone. The Amalgamated is crosscutting; the Lucky Boy is shaft sinking and has reached a depth of about 100 ft.; the North Star is crosscutting

Gold Dust mill and shaft



United Oatman mine



Aztec shaft of the Tom Reed mine

Tom Reed mill

at the 300-ft. level of its 420-ft. shaft; the American is under lease; the 250-ft. shaft of the Lexington is to be sunk an additional 125 ft. and a crosscut extended at the new level; a tunnel, about 500 ft. long, is being driven on the United Republic, and leasers are at work at the Alcyone.

Ransome lists about 82 properties on his map of the Oatman district (Bull. 743, U. S. Geol. Surv.). Out of this number thirteen properties are now active. Opinion upon the future of the district swings between the extremes of optimism and pessimism. The large orebodies in the three larger properties are rapidly approaching exhaustion, and this accounts for the pessimistic opinion. Of the ten smaller properties, three are preparing to mill ore and seven are prospecting.

The critical area of the district is of considerable extent and many properties have been only superficially explored. This accounts for the optimistic opinion. Even the pessimists concede that another large orebody may be discovered. Ransome states that very little ore has been found in the Oatman district below a depth of 1,000 ft., and most of the known orebodies have terminated at depths considerably less than 1,000 ft. In the absence of evidence to the contrary, this opinion throws mining possibilities into the zone relatively near the surface. Within the depth limit and the area indicated there remains ample opportunity for exploration. Leasing may become a method of developing prospects.

Oatman, although distant from railroad transportation, is accessible by good roads and possesses the advantage that mining and metallurgical practice has been established. The broad features of structural and areal

United Oatman mill under construction

geology have been outlined, and the accumulated experience of many can be advantageously applied to future operations. Power from the Kingman Power & Light Co. is available at an average cost of 2.4c. per kw.-hr. on a straight meter basis. Considering the fact that this power is transmitted over 36 miles of line, and is generated by steam, the power rate is low; this is an important advantage to present and future operations.

New Company Will Open Leadore Mine, in Idaho

A firm known as the International Engineering & Finance Co., with headquarters in Spokane, has closed a deal for the property of Leadore Consolidated Mining Co. The Leadore mine is situated at Leadore, in Lemhi County, Idaho, on the Pittsburg & Gilmore R.R. The property consists of thirty-one claims equipped with concentrating plant, buildings, power plant and machinery. The new owners expect to have the plant in operation in the next sixty days, according to J. L. Magney, vice-president. Reports indicate that 670,000 tons of ore is blocked out.

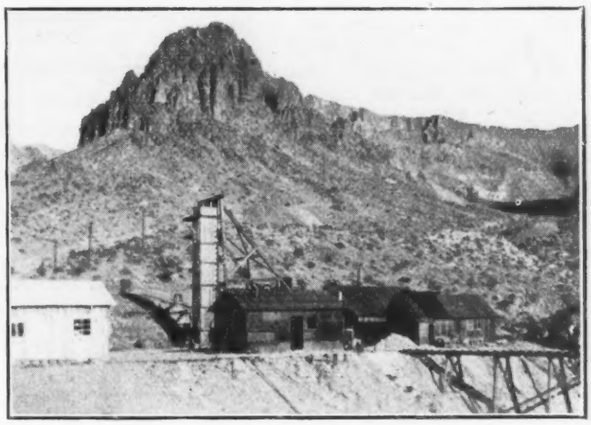
Northwest Magnesite Will Continue During Winter at One-sixth Capacity

Magnesite production at the plant of the Northwest Magnesite Co. at Chewelah, Wash., will continue during the entire winter, according to R. B. Rogers, superintendent.

"We are operating one kiln and are shipping fifty tons a day of dead-burned magnesite," Mr. Rogers said. "Sixty men are employed at the kiln and sixty at the plant. Operations are at about one-sixth capacity."

The American Minerals Co.'s plant at Valley closed Dec. 1 for the winter, but will reopen about March 1.

Telluride mill under construction



Telluride mine plant

Arizona Mining Companies Protest Assessed Valuations

Phelps Dodge, United Eastern and U. V. X. Have Cases Pending—Copper Queen Smelter Taxed for $2,827,064

The Phelps Dodge Corporation has questioned the fairness of the tax assessment for 1923 of the Copper Queen smelter, at Douglas, Ariz., and has protested to the county treasurer. In paying the half year's taxes that became due on Nov. 1, the corporation objected to the valuation as it has been raised by the equalization board, and stated that the amount of taxes, made necessary by the increased valuation, was paid under protest. The assessed valuation of the plant had been raised from $2,526,987.56 to $2,827,064.57.

The United Eastern Mining Co., of Oatman, recently refused to pay the taxes as assessed on the valuation that had been fixed by the board and offered a check for $10,002.76, the amount that was claimed to be just charges. The check was refused by the county treasurer, who stated that the amount due for the half year was nearly twice that which the company offered. This company brought suit in the federal court, attacking the methods used by the tax board in fixing the valuations on which the 1922 taxes were based, and the payment of these taxes is held up because of the litigation.

The taxes for the first half of 1923 also became delinquent upon the refusal of the company to pay the levy demanded.

The United Verde Copper Co. recently withdrew its action attacking the tax assessment methods in Arizona, a suit that was similar to that of the United Eastern's and one brought by the United Verde Extension. The latter company, however, has not withdrawn its suit.

Nipissing Earns More Than $1,080,000 Dividends

During the month of November the Nipissing company of Cobalt, Ont., mined ore of an estimated net value of $185,414 and shipped bullion of an estimated net value of $297,461. The low-grade mill treated 7,041 tons and the high-grade plant 157 tons. The refinery shipped 461,334 oz. of silver as bullion. For the first eleven months of the year production amounted to 3,080,000 oz., having an estimated net value of $1,995,644, so that the output for the year should amount to 3,400,000 oz., or approximately the same as last year. The estimated net value will be slightly lower, as the average price for silver is somewhat less than for 1922, but the net profits will be much the same as for 1922, when they were $1,485,700. The company is paying 12 per cent a year and in addition two bonuses of 3 per cent each, which calls for $1,080,000, so that the dividend is being earned, with a satisfactory margin of safety. The net current surplus stands at about $4,750,000. The company has recently shown greater activity in its search for new properties, and has under option the Powell group in Rouyn, as well as some well located property in South Lorrain.

Cananea Copper Officials Deny Rumors of Early Shutdown

THE Cananea Consolidated Copper Co. of Cananea, Mexico, is now employing about 3,000 men and production is approximately 3,500,000 lb. per month. It was recently announced that rumors of plans for a shutdown of the company's mines were without foundation and that operations would be continued at the present rate. The rumor probably resulted from the fact that the company had stopped production at some of its high-cost mines in an attempt to centralize operations.

Grass Valley, California Gold District, Experiences Boom

The Grass Valley district in California continues to excite mining interest, although outside of the larger properties, the North Star, Empire, Idaho Maryland, and Brunswick, operations are chiefly exploratory or preliminary to exploration. The Alcalde which has been in and out of ore many times, is now milling. The newer companies will extend the mining area and some may be fortunate enough to make important discoveries.

Several Nevada companies have entered the district, the Gold Wedge Divide, Ben Hur Divide, Tonopah North Star, Tonopah Umatilla, and the Hilltop Nevada Co., all having acquired new mining ground. The Hooper tract, two miles east of Grass Valley, is said to have been acquired recently by J. E. McGowan. With four large properties producing actively and several small producers, the entry of a considerable number of prospecting companies has had the effect of directing attention to dormant mining possibilities, with the result that Grass Valley is now one of the most active mining districts in the state.

Tintic Standard Pays $290,000, Biggest Dividend in Several Years

THE Tintic Standard Mining Co. of Eureka, Utah, will on Jan. 5 pay a dividend of 25c. a share, 10c. regular and 15c. extra, amounting to $290,325. This is the largest single dividend paid by a Utah silver-lead mine in recent years. The total for the year will amount to $755,905, and the total in the short history of the mine will be $2,587,912.

New Oreshoot in Old Standard Mine Shows Well

British Columbia Owners Explore in Mexico; Lessees Strike Ore at Home—Has Good Record of Production

Lessees at the old Standard mine at Silverton, B. C., have driven into a new shoot that is said to give promise of being an important discovery. The owners turned the old property over to lessees some four years ago, under the impression that the mine was worked out so far as large-scale company operations were concerned. But during the present year the mine has shipped more than 1,500 tons of concentrates to Trail, zinc concentrate forming by far the largest proportion. The new find appears to be mainly galena ore, running well up in silver. A batch of ore is being put through the mill, and when the returns from this are received a better idea can be formed as to the value of the new find, but some of the old miners are predicting that the Standard will "come back," in the same way that the Slocan Star has done. The Standard paid its shareholders $2,700,000 in dividends, besides about $400,000, which was left in the exchequer when the mine was closed, and from the interest on which the company has been exploring prospects in places as far afield as Mexico. The joke will be "on them" if good ore in large quantity is found in the old mine at home.

Utah-Apex Company Passes Fourth-Quarter Dividend

The Utah-Apex Mining Co., operating at Bingham, Utah, has failed to announce a dividend for the fourth quarter of 1923; the reason is said to be the recession in the price of metals and the large amount of development work done by the company. A new orebody has been opened on the 2,000 level, which measures 10x50 ft., and which assays 15 per cent lead and 5 oz. silver. The company has increased its territory during the last few months by actual purchase of adjoining mining ground and acquisition of capital stock of other companies. The new additions include the Iron Canyon-Bingham Tunnel Co., Coronado group, Jack Rabbit claim, Quinn group, and Bingham and Eastern Mines Co. In the year ended Aug. 31, 1923, the Utah-Apex produced 128,771 tons of ore, of which 54.961 was direct-smelting ore, and 73,819 milling ore. Metal production amounted to 22,661,749 lb. of lead; 9,592,399 lb. of zinc; 1,393,000 lb. of copper, and 402,208 oz. of silver. As of Aug. 31, 1923, the company had in cash and United States certificates of indebtedness, $1,121,605, and no debts. During 1923 four dividends of 25c. each were paid, one being an extra disbursement. Recently a cave caught a number of men including the foreman and superintendent of the mine. The latter was rescued, but the foreman and three others lost their lives.

Active Winter Ahead on Minnesota Iron Ranges

Stripping Operations Keep Many Shovels Busy—New Equipment Ordered

Winter operations on the Mesabi iron range in Minnesota are assuming full swing. At the close of the shipping season, some men were thrown out of employment, due to the closing down of ore operations in the open pits, but many of these have gone to work on winter stripping. The Oliver Iron Mining Co., the largest single employer of labor, is stripping at eleven of its open pits. It is also reopening one underground mine and is starting development of two new properties.

The complete electrification of the Glen mine has been decided upon. The improvements call for a new engine house, which will be provided with a 2,000 cu.ft. air-compressor and 100-kw. rotary converter with transformers, besides a 350,000 c.f.m. ventilating fan. The underground equipment includes three four-ton electric locomotives.

The placing of one order for 20 miles of 100-lb. rail for open-pit work by the Oliver company indicates an active season for 1924. The independent operators as a whole are working their underground properties to capacity and at present stripping work is being done at twelve open pits. Many improvements are contemplated by the various companies with a view to more efficient operation. New equipment is being ordered for open-pit operations.

On the Vermilion Range, prospects are bright for winter operations at all of the underground properties. The Pickands-Mather Company is working its Zenith mine with full crews, and is completing the surface improvements started in the summer. The Oliver company is working three properties and has outlined extensive improvements at the Soudan mine, both underground and on surface. The Chandler mine was a consistent shipper all summer, and no doubt will continue to ship during the winter to the Zenith Furnace Co. at Duluth.

West End Opens Vein in Mabel Mine on 400 Level

The vertical shaft of the Mabel mine, 20 miles from Mina, Nev., operated by the West End Consolidated Mining Co., of Tonopah, has been completed to the 400 level. The north crosscut reached the vein and a west drift has been started on low-grade ore. The drift has some distance to go before getting under the oreshoot developed on the upper levels, and there is every reason to believe that the ore will be as rich and as wide as on those levels. The oreshoot appears to rake to the west, in which direction the company has more than 4,000 ft. of virgin ground to be developed.

More than twenty cars of ore have been shipped from this property since the West End took it in 1921. The last car carried higher values than have been contained in any ore shipped to date, and assayed 2.35 oz. gold, 171 oz. silver, and 20.5 per cent lead; the total gross value was $185 per ton. Development work has been performed on only one vein, although there are several veins which will bear investigation, some of them having produced rich ore from near the surface during early mining operations about fifty years ago.

Million-Dollar Crusher Plant Nears Completion

A PART of the coarse-crushing equipment of the new $1,000,000 crushing plant of the United Verde Copper Co., at Clarkdale, Ariz., was recently given a tryout. Although this division of the plant is completed, it will likely be after Jan. 1 before the entire plant will be in operation. The erection of the new plant will permit the dismantling of the present crusher at Hopewell; it will care for all ore produced by both underground and steam-shovel operations.

Simon Silver-Lead Stops Milling

The Simon Silver-Lead Mines, Inc., near Mina, Nev., ceased milling operations on Dec. 1. Limited development is to be carried on, the principal work being the sinking of the new three compartment shaft from the 550 level, the work to be done on contract. It was deemed advisable to discontinue all ore production while shaft sinking was in progress, and the mill was accordingly shut down.

Cortez Mill Operates Steadily

The Cortez Consolidated is steadily operating its mill at Cortez, Nev., treating about 150 tons of ore per day. The average grade of ore is not known and production value figures are not made public. A new strike is reported near the east branch of the Garrison tunnel, the ore assaying 38 oz. silver across a width of 4 ft., in a vicinity from which a considerable tonnage of bonanza ore has been mined.

In addition to regular company mine operations, there are twenty lessees working in various parts of the mine, with fair results. The ore is of high-grade, as care is taken to discard all waste possible before sending it to the mill.

Anita Copper Co. Suspends Work at Octo Mine

The Anita Copper Co. has suspended operations on the Octo mine, near Lordsburg, N. M., after almost three years of continuous prospecting and development. It is moving all machinery and equipment to an old mine near the Last Chance, about 8 miles from the Octo. A development program has been outlined.

Lucky Jim Mine, Zincton, B. C., Will Be Reopened

High-Grade Zinc Ore Shipped in 1918—Mill May Be Built—A. G. Larson in Charge

The Pohlman Investment Co., of Spokane, has purchased the Lucky Jim mine, at Zincton, B. C., from the Canadian Bank of Commerce, and will reopen it under the supervision of A. G. Larson, one of the principal shareholders in the investment company, as soon as weather conditions allow. The Luck Jim has shipped to smelters in the United States and Canada the richest zinc ore ever sent out of the Slocan in any quantity. The mine fell into financial difficulties during the early stages of the war, and Mr. Larson was appointed by the court to manage the property in the interest of the creditors. Under his management, the first mortgage to Senator Lendrum MacMeans, of Winnipeg, was paid off and about $15,000 on the second mortgage, also held by the Senator, and all the unsecured creditors were paid in full for their claims.

The owners then attempted to operate the mine again themselves, with the result that it fell into the hands of the Canadian Bank of Commerce. There is no mill at the mine, all shipments being high-grade zinc ore. In the mining of this, however, a large quantity of medium-grade ore was broken and either left in the stopes or placed on dumps. It is understood that the new owners purpose to erect a mill to concentrate this material and during the construction of the mill to develop orebodies that Larson thinks he will have no difficulty in finding. The mine has been idle since the early part of 1918, in which year 1,843 tons was shipped, while in the previous year more than 3,000 tons was sent to the smelter.

Indian Development in British Columbia Shows Well

Development at the Indian mine, in the Salmon River district, in British Columbia, continues encouraging. The raise from No. 1 tunnel toward the surface, 263 ft. above, has been advanced 40 ft., all the way through ore running about $100 in gold and silver per ton. Much of the gold and silver is free, the metallics being composed of about 40 per cent gold and 60 per cent silver. The drift on the vein shows this last shoot to be more than 125 ft. long, the face of the drift still being in ore. A crosscut from the drift has passed through 12 ft. of ore, with ore still in the face. A raise has been started from No. 2 adit, and drifting is being continued in No. 3 adit, with a view to picking up the shoots already opened on the No. 1 and No. 2 levels. A large body of milling ore has been developed and the erection of a mill is part of the company's program for next year. Much of the ore now being developed at the end of No. 1 adit is of shipping grade.

News from Washington

By PAUL WOOTON
Special Correspondent

Oddie's Mines Department Bill Indorsed

H. F. Bain and G. O. Smith Approve Measure—A.I.M.E. Directors Defer Action but Appreciate Senator's Efforts

INTRODUCTION by Senator Oddie of his Department of Mines bill is bringing to him a considerable volume of communications commending the measure. H. Foster Bain, the Director of the Bureau of Mines, in a letter to the Nevada Senator, among other things says:

"You will appreciate that as Director of the Bureau of Mines I cannot express an opinion as to whether the creation of a separate department at this time is a proper measure, since a plan for the reorganization of the executive branches is under consideration by the Executive and by Congress. An opinion on that point must come from higher officials. I have no hesitation, however, as a mining man, in expressing my personal conviction that if such a department can be created it will be of the greatest possible service to the country as a whole, as it will to the particular industries in which you and I are especially interested.

"It will be of very great benefit to the mining industry, and accordingly to the public interest, if so far as is possible the various functions of the Federal Government that relate to mines and mining can be brought together. Mining is one of the basic industries. It supplies the raw materials which, with foods and textiles, form the foundation of all industry. It affords the largest part of the freight handled by the transportation systems. Its products at the same time are essential to the maintenance of the transportation agencies. We have seen repeatedly how the stoppage of production in branches of the mining industry paralyzes the whole national life. It is a fact of common observation that inefficiency and waste in the mineral industry react on the whole industrial fabric. There are reasons why waste in the mineral industry is even more important than waste in the food industries.

"Minerals are not re-created. They are not produced in the form of another crop. Any mineral deposit is a wasting asset. The total amount of mineral wealth available cannot be increased. It can be conserved, however, and used wisely. It is fundamental to the safety and the prosperity of the country that the mineral industry should be given thoughtful and careful consideration when legislative programs are framed and when administrative policies are formulated. On this account it is highly desirable that the functions of the government in regard to mines and mining should be centralized so that the spokesmen for the industry may be given a position commensurate with its importance."

Dr. George Otis Smith, the Director of the U. S. Geological Survey, says:

"All who are interested in federal legislation which recognizes and promotes the mineral industry are gratified by the consideration of such a measure as the one you have introduced. The essence of the measure appears to be the utilization of the Geological Survey and the Bureau of Mines, which together form a nucleus of the proposed department. If the department is to be established, these two bureaus, inevitably, must be the foundation upon which it is built."

F. F. Sharpless, in a letter to Senator Oddie, says that the proposal to establish a Department of Mines was discussed at length at the meeting of the Board of Directors of the American Institute of Mining and Metallurgical Engineers, but that no action was taken, pending the report of a committee which is to consider this bill and other mining legislation. "Regardless of the action it may be deemed wise to take," says Mr. Sharpless in his letter, "I want to assure you that our directors are deeply appreciative of your many efforts in behalf of the mining industry. They feel that in you they have a stanch and loyal advocate for every matter of merit in which the mining industry is concerned."

May Transfer Bureau of Mines to Commerce Department

Change Could Be Made by Executive Order—Reassignment of Leasing Work Obstacle

A provision in the organic act of the Department of Commerce apparently paves the way for the transfer to that Department of the Bureau of Mines, the Patent Office, and the Mineral Resources Division of the Geological Survey. The law establishing the Department of Commerce specifies that the President may transfer to it any scientific or statistical bureau the work of which falls within the scope of the department's activities. It is entirely possible that the President may issue an Executive order to the foreging effect prior to Jan. 1. Such an Executive order would carry into effect a portion of the reorganization plan and would be an indication of the sincerity of the administration in its avowed desire to reorganize the federal departments.

The transfer of the Bureau of Mines to the Department of Commerce would facilitate the greater development of the economic side of its work. It doubtless would strengthen relations with the mining industry. The change would make possible closer co-operation with the Bureau of Standards and with the Bureau of Foreign and Domestic Commerce. The change, however, would necessitate the reassignment of the leasing work now performed by the Bureau of Mines. It is assumed that this function would be transferred to the Geological Survey. This is one of the objections to the change, as there are certain advantages in having the leasing work closely tied in with activities of a research character.

Searchlight Flickers as Railroad Is Abandoned

THE Santa Fe R.R. has requested permission from the Interstate Commerce Commission to abandon the 56-mile railroad extending from Goffs to Searchlight, Nev. This road served the Vanderbilt and Searchlight districts as well as a number of contiguous desert points. Mining and prospecting is virtually dead in the vicinity, and the road has very little traffic and is not needed, say the officials of the railroad.

Decision Ready on Ferromanganese Relief Claims

Question of New Appropriations Depends Upon Early Rulings—Further Findings Announced

The Attorney General is about to transmit an opinion to the Secretary of the Interior, it is understood, as to whether or not the production of ferromanganese comes within the scope of the War Minerals Relief Act. If the Attorney General should find that such operations are admissible and if the Secretary of the Interior accepts that interpretation of the act, it will mean that large losses, the aggregate of some fifteen claims, will have to be allowed.

In addition, a decision by the Supreme Court of the District of Columbia is thought to be imminent in the matter of the admissibility of losses growing out of property purchases. The admissibility of interest payments also is before the courts. Until these elements of uncertainty are removed, it is probable that no additional appropiations for war minerals relief will be proposed. If it should develop that payments are not to be made in claims that involve the matter of ferromanganese, and should the courts decide against interest and purchase of property payments. it is probable that no legislation will be needed, as the remainder of the original appropriation probably will be sufficient to discharge all findings of net loss.

The Secretary of the Interior has approved further findings as to net loss as follows: W. H. Cox, $615; W. W. Gibbons, $476; John A. and W. S. Clark.

$704; J. H. Nodine, $270; O. O. Scripture, $280.84. Disallowances have been approved as follows: William H. Milroy, stimulation not established; Robert J. Willard, stimulation not established; John McFarland, commercial importance not established; H. W. Eckel, commercial importance not established; Barendregt, Fagan, Fagan and Wilson, commercial importance not established; John F. Martin, commercial importance not established.

The appeals of the Western Mineral Co. and the Georgia Copper Co. have been denied by the Secretary. The appeal of Young, Milne & Reichman has been granted.

Reno Gets Silver-Use Research by Bureau of Mines

Industry Expected to Add $10,000 to $6,000 Fund—Nevada "Atmosphere" Will Help, It Is Thought

With the co-operation of the producers and fabricators of silver, it is hoped to have available $16,000 for the conduct of the research at Reno, Nev., on additional uses for silver during the first six months of 1924. The Secretary of the Interior already has allocated to the work $4,000 from his reserve fund. Director Bain of the Bureau of Mines has been able to allot $2,000 to the work. It is expected that the producers and the manufacturers of silver will contribute $10,000.

The Secretary of the Interior already has formulated a supplemental estimate for $15,000, to be devoted to this work during the fiscal year beginning July 1. It is expected that the industry will match that amount, dollar for dollar, making available $30,000 to carry the work to July 1, 1925. By that time, it is believed actual accomplishments will have been sufficient to justify more generous appropriations. With that in view, Senator Oddie is planning to introduce a special bill carrying the appropriation for the fiscal year beginning July 1, 1925.

The research work on silver is to be conducted at the Reno experiment station. Some are of the opinion that the work should be conducted in Washington, so as to be nearer the electrical furnaces and other equipment of the manufacturing jewelers, which will have to be used. It was thought, however, that the equipment at the Reno station is sufficient for much of the experimentation which will be necessary, and it is the desire of the Bureau to use its own equipment to the greatest extent possible. Many of the experiments are to be of a character which should not be subjected to the interruptions which would occur were they conducted in a commercial plant where the equipment would have to be used in the conduct of the business. Moreover, it is believed that the atmosphere in Reno will give impetus to the endeavor to better the condition of silver. There the research men will be in close touch with the industry and will be imbued with the urgency of the necessity for increasing the demand for silver.

London Letter

By W. A. Doman

Special Correspondent

London, Dec. 6—At the annual meeting of shareholders of the Consolidated Gold Fields, Lord Harris was in a decidedly cheerful mood. The fortunes of the company seem to have changed. As regards the absence of a list of investments from the report, he remarked that the directors did not think it advisable to let everyone know the changes that had taken place. The "profession" is wondering whether John A. Agnew has had anything to do with this decision. Shareholders welcomed his election to the board on account of his varied experience and his skill in discriminating between good and bad propositions. Hitherto the Gold Fields has shown a kind of parental feeling in the undertakings in which it was interested. Having made itself in a sense morally responsible, the policy—and it is doubtless a good one—has been to see the thing through. People are now wondering whether J. A. Agnew has introduced the policy of cutting losses—also a sound one. In any case shareholders seem happy.

Bwana M'Kubwa May Eclipse Union Minière

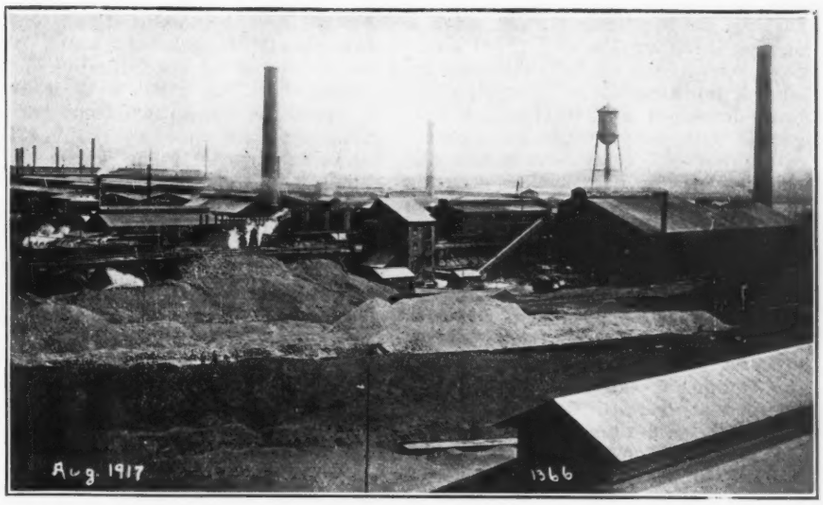
Earlier in the week I met an important personage from East Africa. He told me that the Bwana M'Kubwa is a copper proposition of such vast extent that it will in due course outshine the Katanga deposit worked by the Union Minière. I expressed my doubts, but he maintained the correctness of his view. The deciding factor will be that of cost.

A report has also reached me that Abe Bailey intends taking another mine under his wing. This time it is the Gaika (Rhodesia) that is mentioned. For some years this property was under the management of the Gold Fields. Then a Colonial—S. Edwards—captured it and altered the scheme of underground working. To a certain extent he has achieved success, but all his promises have not materialized. Abe Bailey has certainly revivified Rhodesia from the mining standpoint, mainly by financing the Rezende and Cam & Motor, and by taking up the Sherwood Starr. The public has done well out of the first and second, but doubts are expressed as to the profitability of the Gaika venture.

In April last the F. M. S. Government entered into an arrangement by which it undertook to sell monthly 5 per cent of its holding of tin, amounting to 10,000 tons. It took over this quantity from the producers when the industry was depressed, and to give employment.

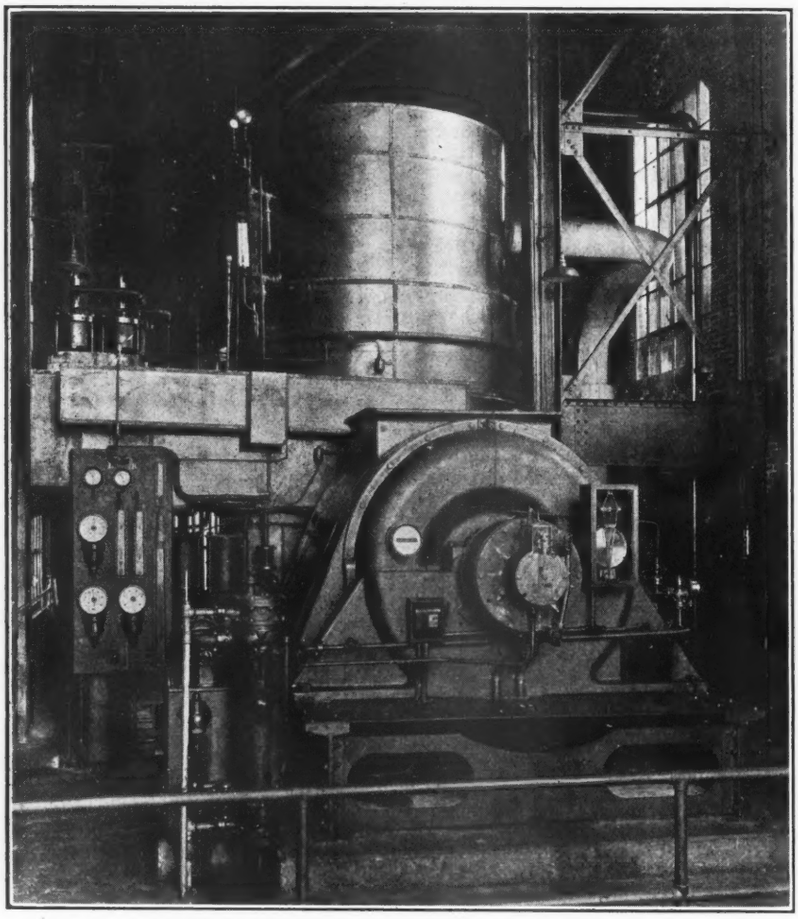
National Smelting Co. Will Get Broken Hill Concentrate

Great Britain is no longer to be dependent upon the German metal octopus—if it should revive—for the National Smelting Co., which was formed by, I believe, R. Tilden Smith in 1917, is being invigorated. It has arranged to acquire from the British Government the contract to purchase zinc concentrates from the Australian Broken Hill companies, made during the war. This contract was to run for ten years, and has still about seven years unexpired. The concentrates will be treated at Swansea Vale and Avonmouth, on which works there has been a capital expenditure of more than £2,000,000. In addition, the National Smelting Co. will acquire 4,000,000 Burma Corporation shares, which means, presumably, that the zinc products of the Burma Corporation will also be treated at Swansea Vale and Avonmouth. The National Smelting Co. has a capital of £1,700,000, of which £1,000,000 is in ordinary shares of £1, £650,000 in 8 per cent cumulative participating preference shares of £1, and £50,000 in deferred shares of 1s. each. As soon as the election is over the public will be invited to subscribe to an issue of £1,500,000 of 7 per cent first-mortgage debenture stock.



General view of the plant of the U. S. Metals Refining Co. at Chrome, N. J.

New Machinery and Inventions



Mercury boiler and turbine installed at Hartford, Conn.

The Emmet Mercury Boiler

A Description of the New Installation at Hartford, the First To Be Placed on a Commercial Load*

WIDESPREAD interest has been aroused over the recent starting up of the mercury boiler and turbine at the Dutch Point Station of the Hartford Electric Light Company. Since this installation was designed, much valuable knowledge has been developed and it should be regarded as a step in the development of the process. There have been a few troubles, mainly in connection with the gas sealing arrangements. It has been run many times and has carried as much as 1,500 kw. At first it was thought that the boiler had been overheated but indications are that this was a mistake. Experiments are proceeding with much caution, but the prospect seems to be very good that the equipment can soon be put into commercial service with conditions practically as designed.

Development of the mercury boiler has been going on steadily since 1914, when W. L. R. Emmet first actively took up the work. Mr. Emmet is a man of ideas, with the requisite resourcefulness and tenacity to carry them through to successful issue. This was evidenced by his fathering of the electric drive for naval work in spite of strenuous opposition from certain quarters at the time, and he has had the satisfaction of seeing it adopted as standard for all capital ships in the United States Navy. The electric drive, however, was a somewhat different proposition from the mercury boiler in that this principle had been well established in stationary practice and it merely had to be adapted to marine work. The mercury boiler, on the other hand, represents pioneer work in which not alone the designs and methods of construction had to be worked out through experimentation, but the thermodynamics also had to be established to a large extent. The Hartford boiler is the fifteenth design to be constructed to date, the others having been tried out with varying degrees of success in the General Electric works at Schenectady. Some of these designs have embodied the fire-tube principle like the Hartford boiler, while others have been of the mercury-tube type. With each the aim has been to construct a boiler that will not require a prohibitive amount of mercury, will not overheat and will be free from injurious expansion strains. Moreover, all joints must be welded to prevent the escape of mercury vapor to the atmosphere and the ingress of air into the system, which would produce oxidization; and finally, the circulation must be such that all liquid will immediately return to the boiler. The problem of designing the turbine has been comparatively simple.

It may be of interest to relate here that in the previous boiler set up at the Schenectady works, a steam load was carried continuously for several weeks to help out the shop demands, and the operation was entirely satisfactory. At the end of this period the boiler was shut down. Up to that time the boiler had been kept full of mercury and, incident to the fact that it was drained and refilled at this time, certain oxide and other solids which had been carried to the boiler by the circulation choked some of the small circulation spaces and caused some of the tubes to be overheated.

For the benefit of those not familiar with the principles involved, it may be pointed out briefly that the process provides for the vaporization of mercury in a boiler (at 35-lb. gage and 812 deg. F., in the present case), expanding the mercury vapor through a turbine and utilizing the heat of the exhaust (at 29 in. vacuum and 414 deg. F. in the Hartford boiler) to generate steam, which is put through a separate turbine or supplied to the station main as at Hartford. That is, the mercury condenser surface is the steam boiler. In this way advantage is taken of a much greater temperature range than is possible with steam alone, and the thermal efficiency approximates that of the internal-combustion engine; namely, a kilowatt-hour at about 11,000 B.t.u.

The possible rate of gain that may be accomplished by the mercury vapor process, as compared with steam plants, is entirely dependent upon the conditions and efficiency of the plant with which the comparison is made. If we compare it with a steam-turbine generating plant running at 200-lb. steam pressure and with the highest standards of efficiency in turbines and auxiliaries, the mercury-steam combination with mercury at 35-lb. gage should, according to Mr. Emmet, give about 52 per cent more output in electricity per pound of fuel; and if in such a plant the boiler room is re-equipped with furnaces and mercury apparatus arranged to burn 18 per cent more fuel, the station capacity with the same steam turbines, condensers, auxiliaries, etc., would be increased about 80 per cent.

*Reprinted from the Dec. 4, 1923, issue of *Power*, a McGraw-Hill publication.

Comparing with stations operating under high steam pressures, the gain would, of course, be less.

The cuts shown represent a section through the outfit, as actually installed at Hartford, with the approximate temperatures indicated. It will be noticed that the turbine and mercury condenser (steam boiler) is above the mercury boiler, so that the condensed mercury returns by gravity and thus eliminates the feed pump. The only pump in the system is a vacuum pump of the water-seal type which sucks through a canton-flannel screen. Every joint in the system is welded so as to avoid any possible leakage of air or mercury vapor.

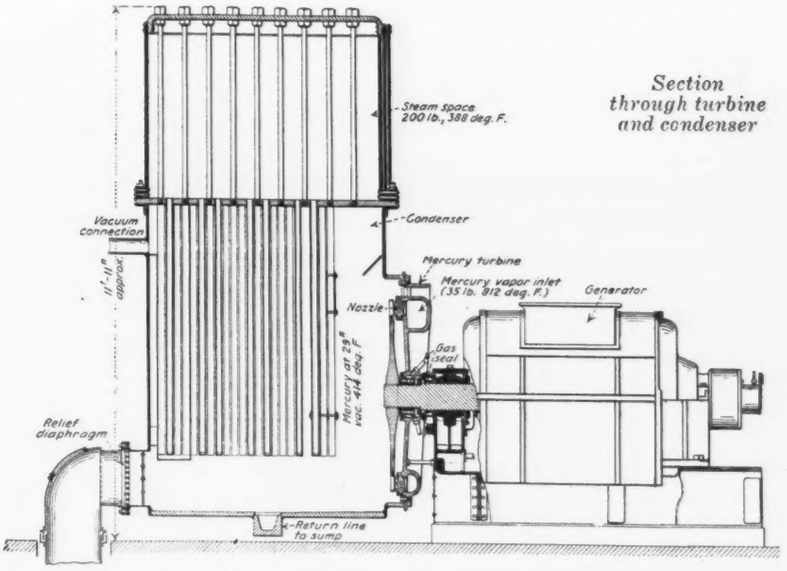
The boiler is oil fired and the flue gases, after passing up through the mercury boiler, are led to a mercury heater or economizer, thence over the steam superheater to the feed-water heater and finally to the stack, at the base of which is an induced-draft fan (not shown). Thus the gases are brought to temperatures equivalent to those employed in steam systems. The mercury vapor passes through the boiler to the turbine, which is of the single-stage impulse type and is expanded to a pressure corresponding to 29 in. of vacuum. From the condenser the mercury liquid flows into a sump and drains back into the boiler. The mercury boiler is of the vertical type, cylindrical in form, and has a single tube sheet into which the tubes are expanded and then welded; the lower ends are free to expand. The lower two-thirds of each tube is hexagonal in shape with the sides slightly curved. These curved sides of adjacent tubes are placed tangent to one another and are welded together at the lower edges, thus taking the place of a bottom tube sheet. The interstices between the tubes hold the mercury. By this arrangement a maximum of heating surface is obtained with a minimum amount of mercury. The present boiler holds about 30,000 lb. of mercury and is designed to evaporate 230,000 lb. of mercury per hour. At this rate the turbine would develop 1,900 kw. and deliver about 28,000 lb. of steam per hour at 200 lb. and 100 deg. superheat; although it is understood that the Hartford installation has not been driven to this capacity, as it has been thought expedient to run at reduced load in order that experience with continued operation may be had.

In general design the mercury turbine is not unlike a steam turbine except that the blading is of tool steel to resist the cutting action of the mercury, and the glands are sealed with illuminating gas. The turbine is bolted to the side of the condenser and then welded. When it is found necessary to shut down the unit, the illuminating gas is turned into the system, and thus prevents the infiltration of air that might cause oxidization of the mercury.

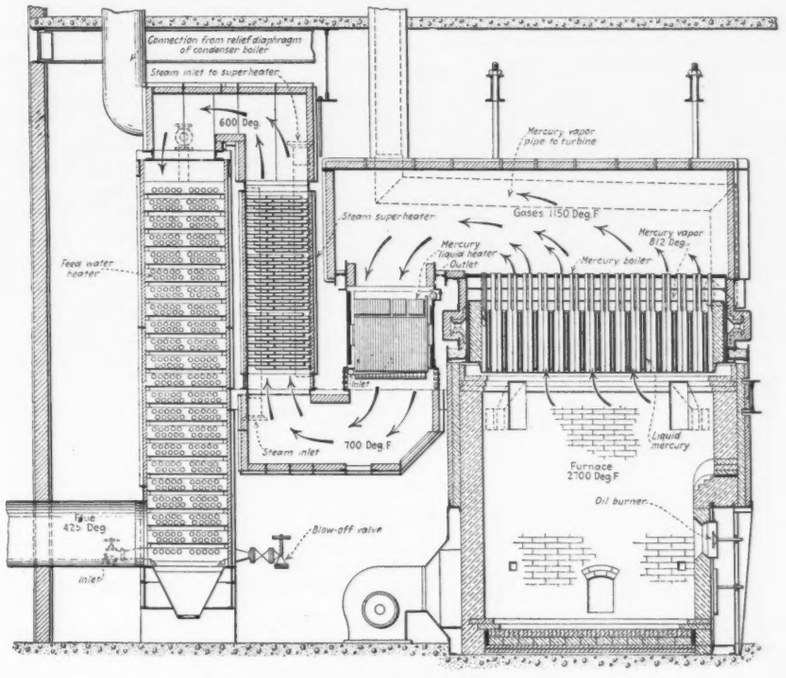
Like the mercury boiler the condenser consists of a vertical cylindrical shell with the tubes rolled and welded into a single upper tube sheet. The tubes are closed at their lower ends, but are not attached to one another. In this way provision is made for free expansion and contraction.

The mercury sump is also under a gas seal and is provided with an ingenious form of strainer consisting of slanting baffles which project into the liquid and carry a wire mesh on their under sides. Any oxide that may be floating on the surface of the mercury is thus caught by the baffles.

As previously stated, the Hartford installation is merely a step in the development. It has two major limitations. The boiler as constructed is inaccessible for cleaning, and the steam pressure, as governed by the existing station conditions, is relatively low (200 lb.). Thus the corresponding temperature involves a lower pressure in the mercury condenser and a greater drop through the turbine than is desirable for highest efficiency in a single-stage machine. Consequently, another boiler is now being designed. It will be of the inverted V-type in which the mercury will be contained within the tubes and the gases pass over them. The lower headers are so arranged that the bottom part of each can be easily severed with a cutting tool, the tubes cleaned and the head welded on again in a comparatively short time. Moreover, it is expected to install this later boiler where the steam conditions are such as to permit operating the mercury turbine under a more favorable pressure range.



Section through turbine and condenser



Section through boiler, heater and superheater

THE MARKET REPORT

Daily Prices of Metals

Dec.	Copper, N. Y. net refinery*	Tin		Lead		Zinc
	Electrolytic	99 Per Cent	Straits	N. Y.	St. L.	St. L.
13	12.85	47.625	48.125	7.35	7.25	6.20@6.25
14	12.875	46.75	47.25	7.35	7.40	6.20
15	12.875	46.625	47.125	7.35	7.40	6.20
17	12.875	46.25	46.75	7.35	7.40	6.20
18	12.875	46.625	47.125	7.35	7.45	6.15@6.20
19	12.75@12.875	46 375	46.875	7.45	7.50	6.15@6.20
Av.	12.860	46.708	47.208	7.367	7.40	6.196

*These prices correspond to the following quotations for copper delivered: Dec. 13th, 13.10c.; 14th, 15th, 17th, and 18th, 13.125c.; 19th, 13.00@13.125c.

The above quotations are our appraisal of the average of the major markets based generally on sales as made and reported by producers and agencies, and represent to the best of our judgment the prevailing values of the metals for deliveries constituting the major markets, reduced to the basis of New York cash, except where St. Louis is the normal basing point, or as otherwise noted. All prices are in cents per pound. copper is commonly sold "delivered," which means that the seller pays the freight from the refinery to the buyer's destination.

Quotations for copper are for ordinary forms of wire bars, ingot bars and cakes. For ingots an extra of 0.05c. per lb. is charged and there are other extras for other shapes. Cathodes are sold at a discount of 0.125c. per lb.

Quotations for zinc are for ordinary Prime Western brands. Quotations for lead reflect prices obtained for common lead, and do not include grades on which a premium is asked.

The quotations are arrived at by a committee consisting of the market editors of *Engineering and Mining Journal-Press* and a special representative of the Bureau of Mines and the Bureau of Foreign and Domestic Commerce.

London

Dec.	Copper			Tin		Lead		Zinc	
	Standard		Electrolytic						
	Spot	3M		Spot	3M	Spot	3M	Spot	3M
13	62 1/4	62 7/8	67 1/2	239 3/4	240 7/8	31 3/4	30	32 3/8	32 1/2
14	62 1/8	62 7/8	67 1/2	236 3/8	237 5/8	31 1/2	29 3/4	32 1/2	32 3/4
17	62 1/2	63 1/4	67 3/4	233 3/8	234 5/8	31 1/2	29 7/8	32 1/2	32 3/4
18	62 3/8	63 1/4	67 3/4	234 1/4	236 1/2	31 3/8	29 7/8	32 5/8	32 7/8
19	62	62 7/8	67 3/4	232 3/4	234 5/8	30 3/4	29 5/8	32 3/4	32 7/8

The above table gives the closing quotations on the London Metal Exchange. All prices in pounds sterling per ton of 2,240 lb.

Silver, Gold, and Sterling Exchange

Dec.	Sterling Exchange "Checks"	Silver		Gold London	Dec.	Sterling Exchange "Checks"	Silver		Gold London
		New York	London				New York	London	
13	4.37	65 1/4	33 7/16	94s 6d	17	4.37 1/2	65 7/8	33 5/8	94s 4d
14	4.37	65 1/2	33 5/8	94s 5d	18	4.37	65 3/4	33 11/16	94s 4d
15	4.37 1/8	65 1/2	33 5/8	.....	19	4.36 3/4	64 3/4	33 3/8	94s 4d

New York quotations are as reported by Handy & Harman and are in cents per troy ounce of bar silver, 999 fine. London silver quotations are in pence per troy ounce of sterling silver, 925 fine. Sterling quotations represent the demand market in the forenoon. Cables command one-quarter of a cent premium.

Metal Markets

New York, Dec. 19, 1923

Copper

The volume of sales has been less than last week. Many producers are quoting 13¼c. delivered still, but sales at this level have been only a few hundred tons, so that their prices are nominal. For first-quarter shipment, the general level at which orders have been booked is 13¼c., many agencies being willing to sell at this price. On last Thursday there was some metal for early delivery sold at 13c. flat, but sales quickly cleaned up the market until today, when another thousand tons or so could be obtained at that level. Producers do not fear any important sag in the market, and realize that 13c. can only be done where copper must be moved quickly. The brass and wire mills continue extremely active, and there seems no reason to think that any drop in consumption is to be feared.

The export demand has been quiet, but prices have ruled somewhat above those at which domestic business could be done, as high as 13.15 to 13.25c. c.i.f. being realized. Rumors have been current that at the meeting to be held on Jan. 2, further breaks in the ranks of the Copper Export Association may be expected, and some predictions have even gone so far as to suggest that the association may be discontinued. This latter contingency, however, does not seem likely.

Copper for forward delivery is somewhat stronger than near-by, and for the second quarter it would probably be difficult to shade 13¼c. delivered.

Lead

The official contract price of lead, as quoted by the American Smelting & Refining Co., was increased from 7.25c. to 7.40c., New York, today, Dec. 19. The lead market is substantially unchanged from last week, except that even higher prices are being asked for near-by deliveries. One producer is quoting as high as 8¼c., New York, though we have not heard of any sales above 7.85c., which was paid for 100 tons as far back as last Friday. A fair tonnage of lead for late January and early February shipment has been sold during the week at 7.25@7.30c., in addition to the substantial tonnage that goes to contract customers of the smelting company at 7.25c. and 7.40c. Our quotations, given elsewhere on this page, represent a weighted average of the business done at unusually variable price levels. In the Middle West, conditions are also extremely unsettled. Quotations as high as 7¾c. are frequently heard, but producers are taking care of their customers so far as they are able at much lower prices than this. Nevertheless, the average price realized on actual sales has worked up to about 7½c., which is well above the price in New York, considering the Smelting company's sales.

Zinc

The slab zinc market is weaker. Not by much, but sufficient to bring quotations not quite 10 points below last week's. The total volume of business was fair, with sales about equally divided between prompt and forward shipment, mostly to galvanizers, forward shipments commanding a slight premium. High-grade continues at 8@8¼c. delivered. Brass special seems a drug on the market.

Tin

Tin has been erratic in price during the week, but buying has been good, not only among dealers but into consuming hands as well. Prices of 99 per cent are variable in their relation to those of Straits, but a discount of one-half cent still obtains on the average. Forward Straits has sold at the same price as spot.

Arrivals of tin, in long tons: Total to Dec. 17, 4,190.

Foreign Exchange

Cable quotations on Tuesday, Dec. 18, were: francs, 5.25c.; lire, 4.3425c.; and Canadian dollars, 2½ per cent discount.

Silver

Silver prices have been well maintained lately on the strength of continued buying orders from China, but as the date approaches when the last steamers sail which will arrive in time for the Chinese New Year, the market is showing an easier tendency.

Mexican Dollars—Dec. 13th, 49⅜; 14th, 50; 15th, 50; 17th, 50¼; 18th, 50¼; 19th, 49⅜.

Other Metals

Quotations cover large wholesale lots unless otherwise specified.

Aluminum — 99 per cent grade, 27c. per lb.; 98 per cent, 26c. London, £115 per long ton.

Antimony — Chinese and Japanese brands, 9@9¼c. W.C.C. brand, 9¾@10¼c. Cookson's "C" grade, 10¾@11¼c. Chinese needle antimony, lump, nominal, 6½ @7½c. per lb. Standard powdered needle antimony (200 mesh), 7½@8½c. per lb. White antimony oxide, Chinese, guaranteed 99 per cent Sb_2O_3, 7.50c.

Bismuth—$2.55 per lb. London, 10s.

Cadmium—75c. per lb. London, 2s. 6d.

Cobalt—$3 per lb. for spot.

Iridium—$275@$300 per oz.

Nickel—27@30c. per lb. for 99 per cent virgin metal. London, £130 long ton.

Palladium—$83 per oz.

Platinum—$125 per oz. London, £29.

Quicksilver — $60 per 75-lb. flask. Quiet. San Francisco wires $59.35. London, £9 15s.

The prices of Magnesium, Molybdenum, Monel Metal, Osmium, Radium, Rhodium, Selenium, Tellurium, Thallium, and Tungsten are unchanged from prices given Dec. 8.

Metallic Ores

Chrome — $19.25@$22, depending upon grade and source. Nominal.

Manganese—38@42c. per long ton unit, seaport, plus duty. Nominal.

Molybdenum—80c. per lb. of MoS_2 for 85 per cent concentrates. Nominal.

Tantalum—Foreign, 60c. per lb. of Ta_2O_5 contained, c.i.f. New York. Contains about 65 per cent Ta_2O_5 and 5 per cent Cb_2O_5.

Domestic grades offered at 90c. per lb. of contained Ta_2O_5. Contains about 54 per cent Ta_2O_5 and 24 per cent Cb_2O_5.

Market limited. Last importations made in March.

Tungsten Ore—High-grade wolframite, $9; high-grade scheelite, $9.50@$10 per unit. Ordinary grades, $8.15@$8.50.

Vanadium—Minimum 50 per cent V_2O_5, $1@$1.25 per lb. Nominal.

Iron Ore, Magnetite, Titanium, and Zircon Ore are unchanged from the quotations published Dec. 8.

Zinc and Lead Ore Markets

Joplin, Mo., Dec. 15—Zinc blende, per ton, high, $44.20; basis 60 per cent zinc, premium, $41.50@$42; Prime Western, $40.50@$41; fines and slimes, $40@ $38; average settling price, all zinc ore, $40.50.

Lead, high, $96.95; basis 80 per cent lead, $93@$105; average settling price, all lead ore, $90.49 per ton.

Shipments for the week: Blende, 15,767; lead, 2,737 tons. Value, all ores the week, $886,350.

Lead ore prices are acknowledged by both buyer and seller to be as high as $101 basis, and there are claims by sellers that $103 and $105 basis offerings were received, but no buyer will acknowledge having bid it.

With a steady demand approximating the output of zinc blende, at a price level insuring a profit on production, the output has steadily improved for several weeks. The rapid advances in lead prices, offering a wider margin of profit, should increase the output of lead, and as the two minerals are found together it may further increase the output of blende.

Platteville, Wis., Dec. 15. — Blende, basis 60 per cent zinc, $46 per ton. Lead, basis 80 per cent lead, $102 per ton. Shipments for the week: Blende, 980 tons; lead, none. Shipments for the year: Blende, 30,892; lead, 750 tons. Shipments for the week to separating plants, 1,861 tons blende.

Non-Metallic Minerals

Asbestos—Crude No. 1, $350@$450; No. 2, $200@$250; spinning fibers, $100@$125; magnesia and compressed sheet fibers, $60@$90; shingle stock, $50@$60; paper stock $30@$40; cement stock, $17@$20; floats, $6@$12. All f.o.b. mines, per short ton, Quebec.

Feldspar—No. 1, $6.60 per long ton, f.o.b. cars; No. 2, $4.50; ground spar, glass trade, $10, f.o.b. mill; pottery grade, $18 per long ton, North Carolina points.

No. 1, not carrying in excess of 10 per cent SiO_2, $7.90 per ton, f.o.b. New Hampshire points.

For other feldspar quotations see issue of Dec. 8th.

Mica—Scrap, $20 per ton; washer, 11c. per lb.; disk, 1½ in., 30c. per lb.; 2x2 in., 55c.; 2x3 in., 80c.; 3x4 in., $1.05; 3x5 in., $1.60; 4x6 in., $2 per lb., North Carolina mines.

Ground mica, 60 mesh, $65 per ton; 80 mesh, $70; 120 mesh, $120; 140 mesh, $125; all f.o.b. North Carolina mills.

Washer and disk mica, $280 per ton; scrap $25 per ton, f.o.b. New Hampshire points. Demand greater than supply.

Barytes, Bauxite, Beryl, Borax, Chalk, China Clay, Diatomaceous Earth, Emery, Fluorspar, Fuller's Earth, Garnet, Graphite, Gypsum, Limestone, Magnesite, Manjak, Monazite, Phosphate, Pumice, Pyrites, Silica, Sulphur, Talc and Tripoli are unchanged from the Dec. 8 prices.

Mineral Products

Arsenious Oxide (white arsenic)—13½c. per lb.

Copper Sulphate—4.75@4.90c. per lb., domestic product.

Potassium Sulphate—Basis 90 per cent, $45.85 per ton.

Sodium Sulphate—$24@$26 per ton, New York.

Sodium Nitrate—$2.45 per 100 lb., ex vessel.

Ferro-Alloys

Ferromanganese — Domestic, 78@82 per cent, generally obtainable at $109 per gross ton, f.o.b. works. Spiegeleisen, 19@21 per cent, $40; 16@19 per cent, $39.

Ferrocerium, Ferrochrome, Ferromolybdenum, Ferrosilicon, Ferrotitanium, Ferrotungsten, Ferro-uranium and Ferrovanadium are unchanged from the prices published Dec. 8.

Metal Products

Copper—Sheets, 21c. base; wire, 15¾c.

Lead Sheets—Cut, 10.50c.; full, 10.25c. per lb.

Nickel Silver—18 per cent Grade A sheets, 28c.

Yellow Metal — Dimension sheets, 18.75c.; rods, 15.75c.

Zinc Sheets—Base price, $9.25 per 100 lb., f.o.b. plant.

Refractories

Bauxite Brick, Chrome Brick, Firebrick, Magnesite Brick, Magnesite Cement, Silica Brick and Zirkite are unchanged from the Dec. 8 prices.

The Iron Trade

Pittsburgh, Dec. 18, 1923

Railroad orders, though not spectacular, make up a very fair tonnage week by week. Rather heavy buying has lately started in galvanized sheets for car roofs, both in car building and in repair work. Rails are quite fully sold up for the first half of the new year.

Oil statistics having rounded the turn, with flush production decreasing, a fair demand for oil country tubular goods is expected in spring, and 1924 may easily show more than 1,000,000 gross tons of oil country tubular goods produced, which would make a fairly good year in that item.

Steel mill operations will taper off a trifle more in the remainder of this month, but it is practically certain that operations will increase during January, after the continuous decline, aggregating fully 25 per cent, since May 1.

Pig Iron—The market is quiet, with prices well held at $23 for Bessemer, $21 for basic and $22 for foundry, f.o.b. Valley furnaces. The merchant furnaces in operation are fairly well sold up for first quarter No idle furnaces are scheduled to go in.

Connellsville Coke—Contracting for first quarter is sluggish: the prompt market is dull. Prompt furnace, $3.85 @$4; prompt foundry $5@$5.50; contract furnace, $4.25@$4.40; contract foundry, $6@$6.50.

Company Reports

New York & Honduras Rosario Mining Co.

Gold, Silver; San Juancito, Honduras

A report of operations of New York & Honduras Rosario Mining Co. for 1922 shows a net profit of $388,560.22 as follows:

Production of gold and silver		$1,066,732.57	
Less freight and expenses on bullion		41,137.56	
Operating income			$1,025,595.01
Deduct operating expenses			621,409.88
Operating profit			$404,185.18
Deduct New York administrative expenses			47,826.60
Net profit from operations			$356,358.58
Other income			56,141.14
			$412,499.72
Other deductions from income			23,939.50
Net profit for year			$388,560.22
Appropriated for reserves			
Mine fire insurance		$5,295.88	
Advances to other companies		16,340.14	
Transit insurance		2,632.32	
Ore depletion		138,559.25	
			162,827.59
Profit for year carried to surplus			$225,732.63
Surplus, Jan. 1, 1922		$1,606,526.38	
Additions, increased value of bonds	$14,581.89		
Deductions			
Dividends paid during 1922	150,000.00	135,418.11	1,471,108.27
Surplus—Dec. 31, 1922			$1,696,840.90

Balance sheet as of Dec. 31, 1922 is given as follows:

Assets

Permanent			
Mines, real estate and concessions		$3,000,000.00	
Plant, buildings, machinery, and equipment	$1,256,106.33		
Less allowance for depreciation	675,789.91		
		580,316.42	
			$3,580,316.42
Current			
Cash		$73,454.88	
Loans receivable plus interest		234,968.73	
Bullion at smelters and in transit at market		142,270.00	
Broken ore in stopes and mill bin at cost		91,467.00	
Materials and supplies at cost		191,771.69	
Bond holdings plus interest		564,610.75	
			1,298,543.95
Other assets			
Investments—capital stock of other companies		$51,853.00	
Advances to other companies less allowance for shrinkage		88,088.11	
Miscellaneous accounts receivable		3,531.64	
			143,472.75
Deferred charges			
Prepaid insurance, taxes and expenses			125,705.96
Total assets			$5,148,039.08

Liabilities

Current, drafts, accounts and taxes payable			$218,304.86
Reserves			
Mine fire insurance		$33,004.77	
Transit insurance		5,159.94	
Depletion of mines		1,194,728.61	
			1,232,893.32
Capital stock			
Authorized and issued 200,000 shares (value $10.00 per share)		$2,000,000.00	
Surplus			
Appreciation of mine valuation (less depletion)	$1,053,918.55		
Earned surplus	642,922.35	1,696,840.90	
			3,696,840.90
			$5,148,039.08

The business of the company proceeded most satisfactorily during the year 1922, with the single interruption of a strike at the mine.

The results of technical operations are indicated in the following table:

Ore reserves at Jan. 1, 1923, tons	196,016
Ounces per ton	
Silver	17.35
Gold	.054
Total silver, oz.	3,399,991
Total gold, oz.	10,531
Development, ft.	4,887
Ore production, tons	68,763
Dry tons treated	69,470
Ounces silver produced	1,449,899
Ounces gold produced	4,357
Bars of doré bullion	928
Average tons milled per day (365 days)	190
Average silver recovery, per cent	88.84
Average gold recovery, per cent	91.79
Average ounces silver recovery, per ton	20.851
Average ounces gold recovered per ton	.0627
Value per ounce of silver sold	$0.6735
Value silver recovered per ton	14.0302
Cost of silver recovered per ton	8.9005
Cost of silver recovered, per ounce	.4273
Net profit on silver recovered, per ton	5.1297
Net profit on silver recovered, per ounce	.2462

Barnes-King Development Co.

Gold, silver; Montana

The records of the Barnes-King Development Co. show the following operating results for the quarter ended Sept. 30, 1923:

Earnings			
Shannon property		$53,449.80	
Interest		1,406.99	
Miscellaneous		133.25	
			$54,990.04
Deduct			
North Moccasin property expense, less old buildings and material sold		$981.45	
Piegan-Gloster property expense less old machinery sold		797.56	
Kendall property expense less power-plant lighting		647.38	
Butte office expense		1,737.20	
Miscellaneous		4,128.85	
			8,292.44
Difference being profit on operations for quarter ended Sept. 30, 1923			$46,697.60

In addition, there was received from the U. S. Treasury Department, $29,150.59, being refund of over-assessment of income tax for the year 1917.

Burma Corporation, Limited

A report for the quarter ended Sept. 30, 1923, of the Burma Corporation states that 59,342 tons of ore was extracted having an average assay value of 22.79 oz. silver, 25.29 per cent lead and 17 per cent zinc. The tonnage extracted is equivalent to an output of 36 tons per man-shift employed underground. A total of 66,360 tons of ore was milled, averaging 22.38 oz. silver, 24.37 per cent lead and 17.43 per cent zinc. This included the re-treatment of 7,171 tons of accumulated mill tailing, averaging 18.48 oz. silver, 16.51 per cent lead and 20.57 per cent zinc. A total of 32,795 tons of leady concentrates was produced, averaging 39.94 oz. silver, 44.74 per cent lead and 19.99 per cent zinc; 3,082 tons of zinc concentrates was produced in the experimental plant, averaging 9.46 oz. silver, 6.29 per cent lead, and 47.89 per cent zinc; 33,899 tons of lead-bearing material was smelted for a production of 12,515 tons of hard lead assaying 101.05 oz. silver per ton.

The refinery produced 11,298 tons of refined lead and 1,273,346 oz. of refined silver.

In addition to the foregoing, 600 tons of antimonial lead was sold and shipped, and 595 tons copper matte produced ready for shipment from treatment of accumulated smelter by-products.

Estimated Revenue and Expenditure

		Total
Estimated gross revenue	Rs. 77,86,500	£519,100
Estimated operating expenditure	45,12,500	300,833
Estimated surplus over working expenditure	Rs. 32,74,000	£218,267
Debenture interest	Rs.3,00,000	£20,000
Estimated income tax	3,78,100	25,207
Estimated depreciation on machinery and plant	5,49,900	36,660
Capital expenditure	3,12,900	20,860

The vertical shaft was stripped to a total depth of 491 ft. below the surface, and masonry lining completed with exception of 20 ft. below No. 4 level. Shifts worked underground and tonnage of ore extracted show satisfactory increases of 59 per cent and 43 per cent respectively over the corresponding period last year.

The fall of .03 tons in the output per man-shift employed underground, as compared with the previous quarter, is due to the recruitment of new Indian labor of lower efficiency than the Chinese. Increased revenue due to increased output and the sale of zinc concentrates, copper matte, and antimonial lead.

German Metal Situation Better

SPECIAL FOREIGN CORRESPONDENCE

THE CONCLUSION of an agreement between the Mission Interalliée de Controle des Usines et des Mines, of Dusseldorf, and the Ruhr mining and metallurgical companies has proved of great importance to the German metal trade, as is shown by the fact that the demand for copper, tin, lead, and nickel is active. The bulk of orders for copper, which is usually a measure of activity in the German metal market, may be roughly put at 6,000 metric tons per month. Most of it is bought for the account of A. E. G., of Berlin, and the Hirsch interests. The latter are known to have good connections with American producers not in the Copper Export Association. Recently they established a community of interest with the Bing Werke, of Nuremberg, a large consumer of half-finished brass. The Hirsch company, with its merchant wing, the Aron Hirsch company of Halberstadt, has large milling facilities and is connected with the Stinnes shipping company of Hamburg. It exports yellow sheets to British India and copper and brass products to South America.

Notwithstanding the slightly improved business situation, the general outlook for the metals still appears clouded. As a matter of fact, about 40 per cent of the staffs of north central and southern metal-consuming firms have been discharged. Nevertheless, the general situation seems to be better than believed to be by many sales managers, who only look upon the unsettled currency question as the key to the situation. The introduction of the so-called gold loan of the Reich, which is based upon the dollar, and of the stable rentemark has already brought about some stability. Money rates have been lowered from 30 or even 50 per cent *a day* to around 5 per cent.

The boards of the Berlin and Hamburg metal exchanges are still refraining from issuing official quotations for the metals, pending settlement of currency problems. This leaves the small consumer at a loss so far as prices are concerned. This is to be attributed to the scarcity of stable money tokens, which handicaps genuine exchange transactions. Covering operations cannot be made without the certainty that forward obligations will be settled with stable money. Balances of foreign money in Germany are small. Only in the occupied territory are consumers willing to pay in terms of dollars, pounds, francs, and guilders, where they have had to do this. The Otto Wolff-Phönix Co., which is an important tin-plate producer, will have to unload burdensome stocks before engaging in new business. The Franco-Belgian regime has failed altogether to master the complicated railway system in the Ruhr. It will take at least another six months before metal consignments from Hamburg will go by old-established routes to western Germany.

German firms have now many affiliations with companies in Holland, Switzerland, and other countries which are taking in copper, old metal, and aluminum directly from American hands or through London. These shipments are landed chiefly in Rotterdam, while those which are destined for Baltic countries, Scandinavia, or Czechoslovakia are often deposited in the free port of Hamburg, or in warehouses of the United Kingdom. Warrants for these shipments are the object of much speculation on the metal exchange. Many dealers have already abandoned German business and have plunged into international commission transactions, by resuming relations with American, Australian, and even Franco-Belgian firms.

Sanguine expectations are being held upon the prospective development of Austrian metal activities. Austria has a number of important metal consumers, such as the Mitterberger Kupfer Co. Every one of the Austrian establishments has close connections in Frankfort, Cologne, Berlin, and Hamburg. German refineries are working up Austrian scrap metal, and although the scrap metal business is of prime importance, it is now extremely quiet.

Lead is still in good demand. The present German production of it is about 45,000 tons per year, secondary lead included. The corroders and electrical manufacturers are using lots of it. Zinc production is believed to be about 36,000 tons.

Gold and Silver Imports and Exports at San Francisco

The statistics indicating the movement of gold and silver into and out of the port of San Francisco during October, 1923, are as follows:

Imports

In Ore and Base Bullion

From	Gold	Silver
Canada	$83,224	$51,843
Nicaragua	56,964	24,580
Mexico	115,525	178,270
Bolivia	14,230	19,287
Peru	58,082	78,406
China	1,354,867	2,119
Dutch East Indies	193,162	86,732
Philippine Islands	145,615	2,399
New Zealand	71,939	89
Australia	.....	.....
Totals	$2,095,606	$443,725
Coin and other bullion	17,991	11,695
Totals	$2,113,597	$455,420

Exports

Foreign		
China	.....	1,124,280
Hongkong	.....	128,749
Totals 1,970,680 oz. silver	.....	$1,253,029
Domestic		
Mexico	$37,325	.....
China	20,000	$2,007,652
Hongkong	30,500	.....
Totals, 3,157,154 oz. silver	$87,825	$2,007,652

The total exports of refined silver for October, 1923, were 5,127,834 oz. The San Francisco price of silver on the basis of declared value for the month was 63.58c. per oz.

The statistics for November, 1923, are as follows:

Imports

In Ore and Base Bullion

From	Gold	Silver
Nicaragua	$44,123	$17,945
Mexico	108,862	210,246
Salvador	860	6
China	123,823	62
Dutch East Indies	352,025	104,802
Philippine Islands	132,360	2,179
New Zealand	113,877	154
Totals	$875,930	$335,394
Coin and other bullion	121,369	29,840
Totals	$997,299	$365,234

Exports

Foreign		
China	.....	$1,879,838
Hongkong	.....	226,540
Totals, 3,355,557 oz.	.....	$2,106,378
Domestic		
Mexico	$41,605	.....
China	.....	$2,151,347
Hongkong	18,300	158,375
Total, 3,642,865 oz.	$59,905	$2,309,722

The total exports of refined silver for November, 1923, were 6,998,422 oz. The San Francisco price of silver on the basis of declared value for the month was 63.10c. per oz.

Transvaal Gold Output

1920-1923

In Fine Ounces

	1920	1921	1922	1923
January	670,503	651,593		764,469
February	625,330	558,137	639,728	704,976
March	707,036	671,123		761,581
April	686,979	681,382	511,338	745,650
May	699,041	687,776	629,786	786,569
June	715,957	678,490	675,697	755,304
July	736,099	689,555	730,635	754,306
August	702,083	711,526	752,490	769,371
September	682,173	691,026	747,089	739,504
October	662,472	707,825	778,159	793,842
November	633,737	704,236	764,476	.....
December	632,215	681,847	790,712	.....
Totals	8,153,625	8,114,516	7,020,111	.....

The total for 1917 was 9,018,084 oz.; for 1918, 8,418,292 oz.; and for 1919, 8,330,091 oz.

MINING STOCKS

Week Ended December 15, 1923

Stock	Exch.	High	Low	Last		Last Div.
COPPER						
Ahmeek	Boston	...	...	58	June 23, Q	$1.50
Alaska-Br. Col.	N. Y. Curb	*55	*50	*50	...	...
Allouez	Boston	...	...	*16	Mar. '19	1.00
Anaconda	New York	38⅛	37¼	37⅛	De. 15, Ja. 21, Q	0.75
Arcadian Consol.	Boston	2⅛	2 3/16	2⅛	...	...
Ariz. Com'l	Boston	...	...	7⅞	July '23,	0.50
Calaveras	N. Y. Curb	1⅜	1¼	1¼	...	...
Calumet & Arizona	Boston	44	43¾	43¾	De. 7, De. 24, Q	0.50
Cal. & Hecla (New)	Boston	19	19	19	De. 1, De. 17	0.50
Centennial	Boston	...	...	7	Dec. '18, SA	1.00
Cerro de Pasco	New York	46⅛	43⅛	46⅛	Oc. 18, No. 1, Q	1.00
Chile Copper	New York	28⅛	27	27⅛	De. 1, De. 29, Q	0.62½
Chino	New York	17⅛	16⅝	17	Sept. '20, Q	0.37½
Con. Cop. Min. (New)	N. Y. Curb	1 3/16	1⅛	1⅛	...	...
Copper Range	Boston	25	25	25	May '23, Q	1.00
Crystal Copper	Boston Curb	79	64	75	...	...
Davis-Daly	Boston	3⅛	3⅛	3⅛	Mar. '20, Q	0.25
East Butte	Boston	4⅛	4⅛	4⅛	Dec. '19, A	0.50
First National	Boston Curb	38	30	36	Feb. '19, SA	0.15
Franklin	Boston	...	...	1	...	...
Gadsden Copper	Boston Curb	*40	*35	*35	...	...
Granby Consol.	New York	15½	12⅛	15½	May '19, Q	1.25
Greene-Cananea	New York	15⅛	15	15	Nov. '20, Q	0.50
Hancock	Boston	...	...	1⅞	...	...
Howe Sound	N. Y. Curb	2⅛	2⅛	2⅛	Ja. 2, Ja 15	0.05
Inspiration Consol.	New York	26⅛	24½	26	De. 20, Ja. 7, Q	0.50
Iron Cap	Boston Curb	4	4	4	May 23, K	0.15
Isle Royale	Boston	18⅛	18⅛	18⅛	Se. 1, Se. 15,	0.50
Kennecott	New York	35	33⅛	34⅛	De. 7, Ja. 2, Q	0.75
Keweenaw	Boston	...	...	*85	...	...
Lake Copper	Boston	1⅛	1⅛	1⅛	...	...
Magma Copper	New York	31	29⅜	30⅛	Jan. '19, Q	0.50
Mason Valley	N. Y. Curb	1⅛	1⅛	1⅛	...	...
Mass Consolidated	Boston	...	...	*99	Nov. '17, Q	1.00
Miami Copper	New York	22⅛	21⅝	22⅛	No. 1, No. 15, Q	0.50
Michigan	Boston	...	...	1⅛	...	...
Mohawk	Boston	*34⅛	*34⅛	*34⅛	Se. 22, Oc. 13,	1.00
Mother Lode Coa.	New York	9⅛	8⅛	8⅛	De. 14, De. 31	0.50
Nevada Consol.	New York	12⅛	11⅞	12	Sept. '20, Q	0.25
New Cornelia	Boston	*16⅜	*16	*16	Au. 3, Au. 20, Q	0.25
New Dominion	N. Y. Curb	2⅛	2⅛	2⅛	...	...
North Butte	Boston	2⅛	2⅛	2⅛	Oct. '18, Q	0.25
Ohio Copper	N. Y. Curb	*87	*78	*81	...	...
Old Dominion	Boston	...	...	17	Dec. '18, Q	1.00
Osceola	Boston	...	...	31½	June '23, Q	1.00
Phelps Dodge	Open Mar.	†150	†140	...	De. 20, Ja. 2 Q	1.00
Quincy	Boston	...	...	22	Mar. '20, Q	1.00
Ray Consolidated	New York	12⅛	11⅛	11⅛	Dec. '20, Q	0.25
Ray Hercules	N. Y. Curb	*24	*24	*24	...	...
St. Mary's Min. Ld.	Boston	...	...	*32½	No. 9, De. 11, K	1.00
Seneca Copper	New York	6⅛	5⅛	6	...	...
Shannon	Boston	*50	*50	*50	Nov. '17, Q	0.25
Shattuck Arizona	New York	7	6⅞	7	Jan. '20, Q	0.25
South Lake	Boston	...	...	¼	...	...
Superior & Boston	Boston	1⅛	1	1⅛	...	...
Tenn. C. & C. cfs.	New York	9⅛	8⅞	9⅛	De. 31, Ja. 15, Q	0.25
Tuolumne	Boston	...	...	*58	May '13,	0.10
United Verde Ex.	N. Y. Curb	27⅛	27	27	Oc. 5, No. 1, Q	1.00
Utah Consol.	Boston	*1	*1	*1	Sept '18,	0.25
Utah Copper	New York	64⅛	63⅛	64⅛	De. 3, De. 15, Q	1.00
Utah Metal & T.	Boston	*30	*25	*30	Dec. '17,	0.30
Victoria	Boston	...	...	*75	...	...
Winona	Boston	...	...	*15	...	...
Wolverine	Boston	...	...	5⅛	...	...
NICKEL-COPPER						
Internat. Nickel	New York	14⅛	12⅛	13⅛	Mar.' 19,	0.50
Internat. Nickel pfd.	New York	81	80	80¼	Oc. 11, No. 1 Q.	1.50
LEAD						
Carnegie Lead & Zinc	Pittsburgh	2⅛	2	2	...	...
National Lead	New York	130⅛	125⅛	126⅛	De. 14, De. 31, Q	2.00
National Lead pfd.	New York	110⅛	110⅛	110⅛	Au. 24, Se. 15 Q	1.75
St. Joseph Lead	New York	23⅛	22⅛	22⅛	Se. 9, Se. 20 Q, X	0.50
ZINC						
Am. Z. L. & S.	New York	7⅞	6⅞	7⅞	May '20,	1.00
Am. Z. L. & S. pfd.	New York	29	27	27	Nov. '20, Q	1.50
Butte C. & Z.	New York	5⅛	5⅛	5⅛	Mar. '23,	0.50
Butte & Superior	New York	16⅛	15	15⅛	Je. 15, Je. 30, Q	0.50
Callahan Zn-Ld.	New York	4⅛	4	4	Dec. '20, Q	0.50
New Jersey Zn.	N. Y. Curb	150⅛	149	149	Oc. 31, No. 10, Q	2.00
United Zinc	N. Y. Curb	...	...	*50	...	...
Yellow Pine	Los Angeles	...	...	*70	June '23, Q	0.03
SILVER						
Alvarado	N. Y. Curb	...	...	1⅜	...	...
Batopilas Mining	New York	...	...	½	Dec. '07, I	0.12½
Beaver Consol.	Toronto	*24⅛	*22	*24⅛	May '20, K	0.03
Candelaria	N. Y. Curb	*3	*2	*2	...	...
Castle-Trethewey	Toronto	*51	*49½	*50	...	...
Coniagas	Toronto	2.40	2.32	2.33	Oc. 19, No. 1, '23	0.02⅞
Crown Reserve	Toronto	*71	*68½	*69	Jan. 17,	0.05
Kerr Lake	N. Y. Curb	2	1⅞	2	Oc. 1, Oc. 15, Q	0.12½
La Rose	Toronto	*21	*21	*21	Apr. '22,	0.10
McKinley-Dar.-Sav.	Toronto	*15⅞	*13	*13⅛	Oct. '20, Q	0.03
Mining Corp. Can.	Toronto	3.11	2.97	2.97	Sept. '20, Q	0.12½
Nipissing	N. Y. Curb	6⅜	6⅛	6⅜	Ja. 1, Ja. 21, QX	0.30
Ontario Silver	New York	9⅛	6⅞	9	Jan. '19, Q	0.50
Temiskaming	Toronto	*35	*32½	*34½	Jan. '20, K	0.04

Stock	Exch.	High	Low	Last		Last Div.
GOLD						
Alaska Gold	New York	⅛	⅛	⅛	...	...
Alaska Juneau	New York	1⅛	1	1	...	...
Boundary Red M.	N. Y. Curb	...	...	*12	...	...
Carson Hill	Boston	2⅛	2⅛	2⅛	...	...
Cresson Consol. G.	N. Y. Curb	3⅛	3 11/16	3⅛	Se. 30, Oc. 10, Q	0.10
Dome Mines	New York	19⅞	19¼	19⅞	De. 31, Ja. 2, Q	0.50
Golden Cycle	Colo. Springs	1.05	1.05	1.05	Dec. '22, Q	0.02
Hollinger Consol.	Toronto	11.55	11.45	11.50	De. 13, Ja. 3, M	0.05
Homestake Mining	New York	57⅛	54⅛	54⅛	De. 20, De. 26 M	0.50
Kirkland Lake	Toronto	*31	*27	*28	...	...
Lake Shore	Toronto	3.45	3.37	3.38	No. 1, No. 15'23Q	0.02
McIntyre-Porcupine	New York	18⅛	18	18¼	De. 1, Ja. 2,	0.25
Portland	Colo. Springs	*50	*45	*50	Oct. '20, Q	0.01
Teck-Hughes	N. Y. Curb	1 3/16	1⅛	1⅛	...	...
Tom Reed	Los Angeles	...	...	*57½	Dec. '19,	0.02
United Eastern	N. Y. Curb	1⅛	*98	1	Oc. 8, Oc. 28, Q	0.15
Vipond Cons.	Toronto	*95⅛	*93⅛	*95	...	...
Wright-Hargreaves	Toronto	3.25	3.00	3.10	Se. 15, Oc. 1, Q	0.02½
Yukon Gold	N. Y. Curb	*75	*60	*75	June '18,	0.02½
GOLD AND SILVER						
Boston-Mont. Corp.	N. Y. Curb	*18	*15	*15	...	...
Con. Cortez	N. Y. Curb	*56	*52	*56	...	...
Con. Virginia	San Francisco	5⅛	4⅛	5⅛	...	...
Continental Mines	N. Y. Curb	...	...	4⅛	...	...
Dolores Esperanza	N. Y. Curb	*75	*75	*75	Jy. 1, Jy. 10 Q	0.05
Jib Consol	N. Y. Curb	...	...	*65	...	...
Tonopah Belmont	N. Y. Curb	*36	*36	*36	Apr. '23, Q	0.05
Tonopah Divide	N. Y. Curb	*38	*36	*37	Se. 22, Oc. 10	0.10
Tonopah Extension	N. Y. Curb	1⅛	1 3/16	1De. 11, Ja. 1		0.05
Tonopah Mining	N. Y. Curb	1 3/16	1 1/16	1 1/16	Se. 30, Oc. 1	0.07½
Unity Gold	N. Y. Curb	2	1	1⅛	...	...
West End Consol.	N. Y. Curb	*65	*63	*65	Mar. '23, Q	0.05
SILVER-LEAD						
Ahumada	Boston Curb	5	4⅞	4⅞	De. 15, Ja. 2, X	0.10
Bingham Mines	Boston	...	...	16	Sept. 19, Q	0.25
Cardiff M. & M.	Salt Lake	1.02½	*97	1.00	Dec. '20,	0.15
Chief Consol.	Boston Curb	3⅛	3 1/16	3⅛	Oc. 10, No. 1, Q	0.10
Columbus Rexall	Salt Lake	*28⅛	*20	*28	Aug. '22,	0.03
Consol. M. & S.	Montreal	27⅛	27	27	Oct. '20, Q	0.62½
Erupcion	Boston Curb	1⅞	1⅞	1⅞	De. 15, Ja. 2, X	0.125
Federal M. & S.	New York	10	9¼	9¼	Jan., '09,	1.50
Federal M. & S. pfd.	New York	42	42	42	No. 26, De. 15,	1.75
Florence Silver	Spokane	*13⅜	*13	*13⅜	Apr. '19, Q, X	0.01
Hecla Mining	N. Y. Curb	8⅞	8⅛	8⅞	Au. 15, Se. 15	0.15½
Iron Blossom Con.	N. Y. Curb	....	....	*31	Oct. 25, '23,	0.02
Marsh Mines	N. Y. Curb	...	...	*9	June '21, I	0.02½
Park City	Salt Lake	3.87½	3.80	3.87½	Se. 15, Oc. 1 Q	0.12
Park Utah	N. Y. Curb	....	....	3	Ja. 1, Q	0.15
Prince Consol.	Salt Lake	...	...	*75	Nov. '17,	0.02
Silversmith	Spokane	*32½	*30	*32½	Oc. 1, Oc. 10	0.01
Simon Silver-Lead	N. Y. Curb	*1	*1	*1	...	...
Snowstorm Silver-L.	N. Y. Curb	...	...	*46	...	...
Tamarack-Custer	Spokane	1.38	1.25	1.35	Se. 30, Oc. 1, K	0.02
Tintic Standard	Salt Lake	4.00	3.95	3.95	Se. 24, Se. 29	0.15
Utah-Apex	Boston	2⅛	2⅛	2⅛	June '23, Q, X	0.50
IRON						
Bethlehem Steel	New York	54⅜	52⅛	53⅛	De. 1, Ja. 2, Q	1.25
Char. Iron	Detroit	1 1/16	⅞	⅞	...	...
Char. Iron pfd	Detroit	...	...	1⅛	...	...
Colorado Fuel & Iron	New York	25	23¼	23⅛	No. 10, No. 26 Q	2.00
Col. Fuel & Iron pfd.	New York	...	...	102	Feb. '23, Q	2.00
Gt. North'n Iron Ore	New York	30⅛	28⅛	29	Apr. '23	1.00
Inland Steel	N. Y. Curb	...	...	46	No. 15, De. 1Q	0.62½
Mesabi Iron	N. Y. Curb	...	...	5	...	...
Replogle Steel	New York	13⅛	12⅛	12⅛	...	...
Republic I. & S.	New York	50⅛	47⅛	49⅛	May '21	1.50
Republic I. S. pfd.	New York	93	92⅛	93	De. 15, Ja. 2 Q	1.75
Sloss-Sheffield S. & I.	New York	60⅛	54	60	Feb. '21,	1.50
Sloss-Shef. S. & I. pfd.	New York	84	82	84	De. 20, Ja. 2, Q	1.75
U. S. Steel	New York	96⅛	94	95⅛	No. 29, De. 29, Q	1.50
U. S. Steel pfd.	New York	120	119	120	No. 4, No. 28, Q	1.75
Virginia I. C. & C.	New York	53	52	53	De. 15, Ja. 2	1.50
Virginia I.C.&C.pfd.	New York	80	80	80	De. 15, Ja. 22	2.50
VANADIUM						
Vanadium Corp.	New York	32⅜	29⅝	32⅜	Jan. '21, Q	1.00
ASBESTOS						
Asbestos Corp	Montreal	33⅛	33⅛	33⅛	Se. 29, Oc. 15 Q	1.00
Asbestos Corp. pfd.	Montreal	61⅛	61⅛	61⅛	Se. 29, Oc. 15 Q	1.50
SULPHUR						
Freeport Texas	New York	13	12	12⅛	Nov. '19, Q	1.00
Texas Gulf	New York	59⅛	58	59	De. 1, De. 15 QX	2.00
PLATINUM						
So. Am. Gold & P.	N. Y. Curb	3⅛	3⅛	3⅛	...	...
MINING, SMELTING AND REFINING						
Amer. Metal	New York	44⅛	43	43⅛	No. 17, De. 1, Q	0.75
Amer. Metal pfd.	New York	109	109	109	No. 19, De 1, Q	1.75
Amer. Sm. & Ref.	New York	59⅛	57⅞	58⅜	Oc. 11, No. 1, Q	1.25
Amer. Sm. & Ref. pfd	New York	96⅛	95⅞	96⅛	No. 9, De. 1,	1.75
U. S. Sm. R. & M.	New York	22	20⅞	21	Jan. '21, Q	0.50
U.S. Sm.R.& M. pfd.	New York	40⅛	40⅛	40⅛	Oc. 8, Oc. 15, Q	0.87½

*Cents per share. †Bid or asked. Q, Quarterly. SA, Semi-annually. M, Monthly. K, Irregular. I, Initial. X, Includes extra.

Toronto quotations courtesy Arthur E. Moysey; Spokane, Pohlman Investment Co.; Salt Lake, Stock and Mining Exchange; Los Angeles, Chamber of Mines and Oil; Colorado Springs, Colorado Springs Stock Exchange.